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New Research and Trends in Higher Education

Edited by
Maria José Sousa, Fátima Suleman, Pere Mercadé Melé and Jesús Molina Gómez

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About the Editors

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Preface to "New Research and Trends in Higher Education"

In the field of higher education, new approaches, contexts, and technologies are creating a lot of interest, and this Special Issue aims to explore current research and trends in all aspects of higher education. It will act as a global focal point for the study and reporting of a wide range of issues influencing higher education learning processes, including learning innovations, new pedagogical methodologies, and new learning environments.

On the following topics, the book contains unique research contributions, such as research papers, case studies, and demonstrations with original scientific results, methodological elements, concepts, and educational technologies: (a) Technological Advances in Higher Education: mobile technology, virtual environments, augmented reality, automation and robots, and other universal learning tools, with an emphasis on concerns that are not addressed by existing research. (b) Mobile learning, eLearning, Game-based Learning, social media in education, innovative learning models and technologies, and wearable technology for education are all examples of digital higher education. (c) Case Studies in Higher Education: empirical studies on digital technologies, new methodology, new evaluation approaches and tools, perceptions of learning process efficiency, and digital learning best practices in higher education. This book is target to all the educational actors, students, and stakeholders.

Maria José Sousa, Fátima Suleman, Pere Mercadé Melé, Jesús Molina Gómez
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Editorial

New Research and Trends in Higher Education

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1. Introduction

New methodologies, contexts, and technologies are generating a lot of interest in the field of higher education, and this Special Issue intends to address the current research and trends in all dimensions of higher education. It will serve as a global focal point for the examination and reporting of a wide range of issues affecting higher education learning processes: innovations in learning, new pedagogical methods and new learning contexts. The Special Issue includes original research contributions, such as research papers, case studies and demonstrations with original scientific results, methodological aspects, concepts and educational technologies on the following topics: (a) Technological Developments in Higher Education: mobile technology, virtual environments, augmented reality, automation and robotics and other tools for universal learning, focusing on issues that are not addressed by existing research. (b) Digital Higher Education: mobile learning, eLearning, Game-based Learning, social media in education, new learning models and technologies and wearable technologies for education. (c) Case Studies in Higher Education: empirical studies in higher education regarding digital technologies, new methodologies, new evaluation techniques and tools, perceptions of learning processes efficiency and digital learning best practices.

2. New Research and Trends in Higher Education Special Issue Overview

The Special Issue includes 26 articles (Table 1) that discusses the social responsibility among higher education students; the use of storytelling towards becoming more autoethnographic in academia; the Spanish adaptation of a motivational climate scale with university students; the emotional and spiritual intelligence of future leaders: challenges for education; how to measure the degree of academic satisfaction; transversal competences in engineering degrees: integrating content and foreign language teaching; theoretical learning analytics frameworks for stem education virtual reality applications; the interaction between higher education institutions and professional bodies in the context of digital transformation; student-centered and ICT-enabled learning models in veterinarian programs: what changed with COVID-19; upgrading a learning context: evaluation of Sentra's educational project; the unbearable lightness of academic fraud: Portuguese higher education students' perceptions; distance learning perceptions from higher education students—the case of Portugal; a study of the emotional intelligence and personality traits of university finance students; student burnout: a case study about a Portuguese public university; mechatronics: experiential learning and the stimulation of thinking skills; higher education and employability skills: barriers and facilitators of employer engagement at local level; teaching sentiment in emergency online learning—a conceptual model; development and psychometric properties of a scale to measure resilience

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among Portuguese university students: resilience scale-10; using peer review for student performance enhancement: experiences in a multidisciplinary higher education setting; cyber-archaeometry: novel research and learning subject overview; does postsecondary education attainment matter in community service engagement? evidence from across 18 OECD countries; the soft skills of special education teachers: evidence from the literature; learner-centred learning tasks in higher education: a study on perception among students; STEM faculty instructional data-use practices: informing teaching practice and students' reflection on students' learning; drawing skills of candidates for architectural studies vs. learning outcomes of graduates: comparative research based on the example of the faculty of architecture; and life science students' understanding of the role of plants in the ecosystem—a concept network analysis.

Table 1. Articles in the Special Issue.

Author	Title	Keywords
[1] Au-Yong-Oliveira, Manuel	Using Reflexive, Introspective and Storytelling Tools: Towards Becoming More Autoethnographic in Academia	Patagonia; trekking; nature; goodness of humankind; culture; individuality; reflexivity; qualitative research
[2] Berei, Emese	The Social Responsibility among Higher Education Students	higher education students; social responsibility; private and state institutions; romania
[3] Granero-Gallegos, Antonio; Carrasco-Poyatos, María	Spanish Adaptation of Motivational Climate in Education Scale with University Students	validation; mastery; task; performance; ego
[4] Samul, Joanna	Emotional and Spiritual Intelligence of Future Leaders: Challenges for Education	spiritual intelligence; emotional intelligence; leadership; education
[5] Walter, Cicero; Miranda Veloso, Cláudia; Au-Yong-Oliveira, Manuel	Measuring the Degree of Academic Satisfaction: The Case of a Brazilian National Institute	satisfaction; educational management; average satisfaction index; IFPI; Brazil
[6] Oksana, Polyakova; Galstyan-Sargsyan, Ruzana; López-Jiménez, P.; Pérez-Sánchez, Modesto	Transversal Competences in Engineering Degrees: Integrating Content and Foreign Language Teaching	transversal competences; engineering students; higher education
[7] Christopoulos, Athanasios; Pellas, Nikolaos; Laakso, Mikko-Jussi	A Learning Analytics Theoretical Framework for STEM Education Virtual Reality Applications	virtual reality; learning analytics; STEM education; instructional design
[8] Bonzanini, Osmar; Silva, Amélia; Cokins, Gary; Gonçalves, Maria	The Interaction between Higher Education Institutions and Professional Bodies in the Context of Digital Transformation: The Case of Brazilian Accountants	accountant; professions; digital; professional bodies; higher education institutions
[9] Gonçalves, Eva; Capucha, Luís	Student-Centered and ICT-Enabled Learning Models in Veterinarian Programs: What Changed with COVID-19?	learning models; use of icts; higher education; veterinarian education; COVID-19

Table 1. *Cont.*

Author	Title	Keywords
[10] Querido, Lara; Capucha, Luís; Nunes, Nuno	Upgrading a Learning Context: Evaluation of Sintra's Educational Project	learning contexts; operational assistants; training; evaluation; higher education; educational public policies
[11] Ramos, Rosária; Gonçalves, Joaquim; Gonçalves, Sónia	The Unbearable Lightness of Academic Fraud: Portuguese Higher Education Students' Perceptions	academic fraud; academic integrity; higher education; perceptions; students
[12] Gonçalves, Sónia; Sousa, Maria; Pereira, Fernanda	Distance Learning Perceptions from Higher Education Students—The Case of Portugal	distance learning; higher education; online learning; digital pedagogies; students
[13] Rosales-Pérez, Ana; Fernández-Gámez, Manuel; Torroba-Díaz, Macarena; Molina-Gómez, Jesús	A Study of the Emotional Intelligence and Personality Traits of University Finance Students	financial education; emotional intelligence; personality traits; financial behavior; university students
[14] Salgado, Sofia; Au-Yong-Oliveira, Manuel	Student Burnout: A Case Study about a Portuguese Public University	academic burnout; stress; higher education; quantitative research; coping strategies; medication
[15] Habib, Maki; Nagata, Fusaomi; Watanabe, Keigo	Mechatronics: Experiential Learning and the Stimulation of Thinking Skills	mechatronics; experiential learning; creative thinking; critical thinking; robotics; thinking skills; subsumption architecture; mobile robot; educational system; project-based learning
[16] Suleman, Fátima; Videira, Pedro; Araújo, Emília	Higher Education and Employability Skills: Barriers and Facilitators of Employer Engagement at Local Level	higher education; employers' engagement; employability; multi-stakeholder partnership
[17] Martinho, Domingos; Sobreiro, Pedro; Vardasca, Ricardo	Teaching Sentiment in Emergency Online Learning—A Conceptual Model	COVID-19; emergency online learning; emergency online teaching; higher education; lecturers; online learning; portugal; sentiment analysis
[18] Jardim, Jacinto; Pereira, Anabela; Bártolo, Ana	Development and Psychometric Properties of a Scale to Measure Resilience among Portuguese University Students: Resilience Scale-10	resilience; validity; higher education; resilience scale-10
[19] Serrano-Aguilera, Juan; Tocino, Alicia; Fortes, Sergio; Martín, Cristian; Mercadé-Melé, Pere; Moreno-Sáez, Rafael; Muñoz, Antonio; Palomo-Hierro, Sara; Torres, Antoni	Using Peer Review for Student Performance Enhancement: Experiences in a Multidisciplinary Higher Education Setting	peer assessment; peer review; collaborative evaluation; higher education; rubric
[20] Liritzis, Ioannis; Volonakis, Pantelis	Cyber-Archaeometry: Novel Research and Learning Subject Overview	educational; virtual environment; virtual reality; gamification; 3d modeling; cultural heritage; cyber-archaeology; microscope

Table 1. *Cont.*

Author	Title	Keywords
[21] Gong, Hee; Hong, Jung	Does Postsecondary Education Attainment Matter in Community Service Engagement? Evidence from Across 18 OECD Countries	postsecondary education; higher education; community service; civic engagement; educational attainment; OECD country; hierarchical linear model (HLM); PIAAC
[22] Fernandes, Patrícia; Jardim, Jacinto; Lopes, Maria	The Soft Skills of Special Education Teachers: Evidence from the Literature	soft skills; inclusion; teachers of special education; teacher profile; effective communication
[23] Li, Junmin	Learner-Centred Learning Tasks in Higher Education: A Study on Perception among Students	self-directed learning; learning tasks; student surveys; university didactics
[24] Lenhart, Cindy; Bouwma-Gearhart, Jana	STEM Faculty Instructional Data-Use Practices: Informing Teaching Practice and Students' Reflection on Students' Learning	STEM; undergraduates; instructional data; teaching practices; instructional technology; assessment; student reflection on learning; policy
[25] Gawlak, Agata; Pruszewicz-Sipińska, Ewa; Bonenberg, Wojciech	Drawing Skills of Candidates for Architectural Studies vs. Learning Outcomes of Graduates. Comparative Research Based on the Example of The Faculty of Architecture, Poznan University of Technology	architectural education; architectural studies; admission exam in drawing; higher education; drawing
[26] Södervik, Ilona; Nousiainen, Maija; Koponen, Ismo.	First-Year Life Science Students' Understanding of the Role of Plants in the Ecosystem—A Concept Network Analysis	concept; knowledge integration; macro-concept; language of science; network analysis; photosynthesis; biology education; science education; higher education

To create an overview of the new research and trends in higher education, an analysis of the articles is presented using the VOSViewer software to show the network of the research attributes included in title and abstracts, as well as the co-authorship network.

2.1. Co-Authorship

Vosviewer is a program for creating networks and analyzing the strength of associations between variables—in this case, the co-authorships are being analyzed.

Because of the highly interdisciplinary nature of the studies, researchers are coming from different domains, such as education, computer science, management, psychology and others, where complementary advantages could be achieved through cooperation. Creating and analyzing the knowledge maps of the co-authorship network of productive authors can provide valuable information for research centers to develop cooperation groups and for individual researchers to seek cooperation.

In this sense, Figure 1 illustrates the network of the authors of the papers under analysis.

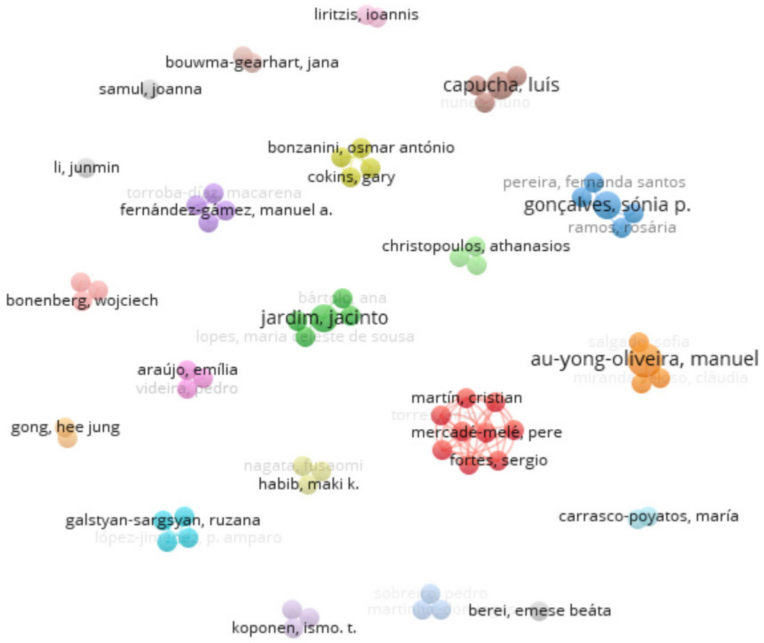

Figure 1. Co-authorship network.

Figure 1 shows the nodes representing the authors, and the node size indicates the number of published articles. The link connecting two nodes represents the cooperative relation between two authors, and the thickness of the link stands for the intensity of cooperation. Overall, the cooperation among productive authors is not close, however, there are several co-authorship groups. Co-authoring publications have critical significance for promoting research innovation and knowledge sharing, as well as improving the quality of research. However, according to the analysis results on main research groups, most productive authors are in fact independent authors (grey nodes in Figure 1), and the scale of such cooperation is nevertheless small and unstable, lacking effective international exchange and cooperation.

2.2. Keywords

Regarding the keywords (Figure 2), there is a strong link strength between several keywords, based on equal distance. Higher education is the strongest keyword represented in the network. However, there are several keywords without association, represented in the orbit of the network. These are: higher education students; virtual reality; learning tasks; creative thinking; assessment; emotional intelligence; culture; and effective communication.

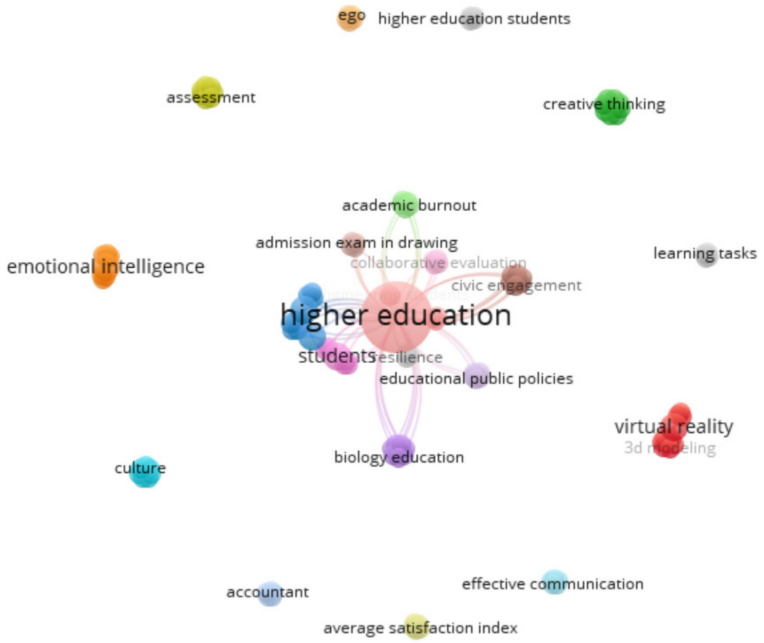

Figure 2. Keyword network.

2.3. Research Attributes and Expressions in Title and Abstract

The network regarding research attributes and expressions in title and abstract (Figure 3) is more complex, and represents six clusters. The purple cluster is related to the motivational climate and the university students, the orange cluster is related with tasks and integration, the red cluster is focused on the application and the outcomes of education, the yellow cluster is focused on the learning process and quality, the green cluster is related to impact and attitude in relation to higher education, and the dark blue cluster is related to the faculty, the practice and the COVID-19 context.

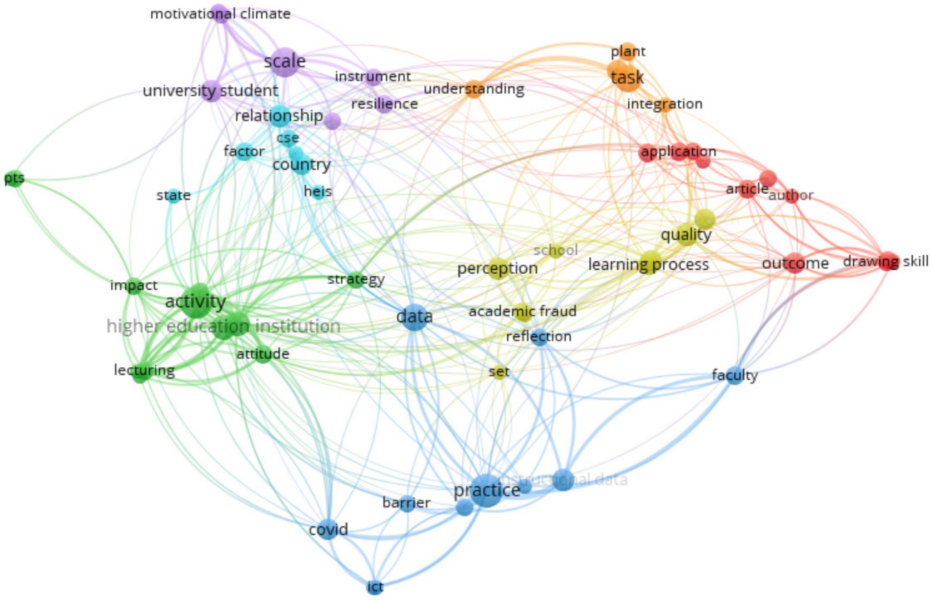

Figure 3. Research attributes and expressions in the title and abstract.

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and J.M.G.; writing—review and editing, M.J.S., F.S., P.M.M. and J.M.G. All authors have read and agreed to the published version of the manuscript.

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First-Year Life Science Students' Understanding of the Role of Plants in the Ecosystem—A Concept Network Analysis

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Abstract: The purpose of this study is to increase the understanding about undergraduate life science students' conceptions concerning the role of photosynthesizing plants in the ecosystem, utilizing a network analysis method. Science learning requires the integration and linking of abstract and often counterintuitive concepts successfully into multifaceted networks. The quality of these networks, together with their abilities to communicate via the language of science, influences students' success in academic, verbal problem-solving tasks. This study contributes to investigating students' understanding, utilizing a modern network analysis method in exploring first-year university life science students' written answers. In this study, a total of 150 first-year life science students answered two open-ended tasks related to the role of photosynthesizing plants in the ecosystem. A network analysis tool was used in exploring the occurrence of different-level science concepts and the interrelatedness between these concepts in students' verbal outputs. The results showed that the richness of concept networks and students' use of macro-concepts were remarkably varied between the tasks. Higher communicability measures were connected to the more abundant existence of macro-concepts in the task concerning the role of plants from the food-chain perspective. In the answers for the task concerning the role of plants regarding the atmosphere, the students operated mainly with single facts, and there were only minor interconnections made between the central concepts. On the basis of these results, the need for more all-encompassing biology teaching concerning complex environmental and socio-economic problems became evident. Thus, methodological and pedagogical contributions are discussed.

Keywords: concept; knowledge integration; macro-concept; language of science; network analysis; photosynthesis; biology education; science education; higher education

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1. Introduction

Research has shown that students come to science classrooms with a heterogeneous level and quality of prior knowledge that significantly influences and sometimes remarkably hinders learning [1–3]. Science learning requires the construction of a solid conceptual knowledge base, which means understanding a large number of abstract, complex and even counterintuitive concepts, their relationships, and the flexible use of this knowledge in problem-solving. This typically poses challenges for many students, not only at elementary and upper-secondary school levels but also in higher education [4–8]. Science operates via abstract scientific concepts (e.g., photosynthesis, ecosystems) that significantly differ from everyday concepts, and, typically, mastering them requires systematic, intentional, and deliberate learning and instruction [9]. As a result of successful science learning, concepts gradually become linked to form complex and hierarchical networks [10]. The richness and organization of these networks play a crucial role in the learning of complex contents and impact the quality of a learner's cognitive processing and problem-solving skills [10].

Text reading and writing are still the most common learning activities in higher education. However, students' verbal outputs for science tasks indicate not only their

topic-specific conceptions but also their ability to use and operate within science language meaningfully. The language of science builds on interconnected science concepts, and first-year university students are expected to learn to understand and use this discipline-specific language, with its unique rules, as part of their subject studies. However, this aspect is often more or less ignored in science education, particularly at university level, although it poses challenges for novice students, who may not yet have the appropriate skills to communicate using the language of science that is designed for highly expert audiences [11].

There is a need for sophisticated tools to investigate the quality of students' verbal assignments from the perspectives of richness, quality and the interconnectedness of concepts and language in general. In that regard, network analysis methods that enable exploring and analyzing students' use of science language have shown potential but, typically, these attempts have not considered the semantic hierarchy of concepts related to a particular science phenomenon, or if they have, the analysis has been extremely laborious. Therefore, the aim of this study is to investigate first-year life science students' written answers concerning the role of plants in the ecosystem by utilizing a newly developed network analysis tool that makes it possible to investigate lexicons that reflect students' ability to operate with different-level concepts.

1.1. Learning Science—From Single Facts to Networks of Concepts

During school years, the students acquire a large number of science concepts and link them in a semantic knowledge network as a part of broader ontologies and explanatory systems. Gradually, the networks are enriched with new concepts and refined so that more and better connections are made between the concepts. The quality of such a network is reflected in structures that are tightly connected and web-like, or hierarchically organized [12–15].

The repeated activation of connections in a knowledge network results in knowledge integration and the forming of so-called macro-concepts, under which many lower-level details, patterns and interrelations of information are organized. Macro-concepts in concept networks can be considered as analogous to key species in food webs so that their occurrence is a prerequisite for several other concepts and contents to be understood. Based on previous studies, the development of macro-concepts shows a move toward more abstracted and integrated concepts in denser knowledge structures [10]. These processes lay the foundation for higher-level cognitive processing, such as problem-solving and case processing, in which conceptual knowledge needs to be flexibly used and applied.

However, the formation of appropriate conceptual understanding does not happen by piling fact over fact; instead, learning science requires a considerable restructuring of conceptual knowledge and conceptual changes in different phases and levels of studies [3]. As a consequence, based on extensive previous studies, we know today that even university students struggle to learn life science concepts and complex contents, and they may have tenacious misconceptions related to the central concepts [3,16,17]. The challenges can be partly explained by the complex, dense and even counterintuitive nature of science concepts. Science concepts often develop simplified meanings in everyday language, providing what is seemingly enough explanatory power in everyday contexts, but leading to misinterpretations if used when aiming to explain complex science phenomena in science classrooms [18]. Additionally, science concepts differ, not only from everyday concepts, but they also may have somewhat varying meanings across disciplines. Learning that a familiar word may have an unfamiliar meaning in a new context is likely to be problematic [19]. The concept of energy, for example, is one of the most central and richly connected ideas across all science disciplines that is studied several times during school years in various contexts, and students at different school levels struggle to understand it properly [20].

1.2. Learning the Language of Science

Learning the language of science has been identified as an important part of learning science. In general, language is central in the development of scientific thinking [21], and learning the specific way to use scientific terms and concepts is central [22]. We can claim that science has its own language because it has its own vocabulary, semantics and syntax and, therefore, some researchers call it the language of science (see, e.g., [23]). These features are important, for example in building meaning between scientific claims, in presenting evidence supporting scientific theories, and other ways to communicate science [24]. The language of science differs greatly from everyday language, and it has been developed for practical reasons. Scientific language is used in communication between scientists and about science; science is reported and communicated through speaking and writing [22,25]. Language is then an important technology and an indisputable part of science. Language can be seen as a vehicle for conducting science and building up scientific understanding [26]. However, language can restrict or impede science learning [27], which is why the use of scientific language should receive more attention in science classrooms.

School science is different from real science, but they have a common ground, the language of science. However, science teachers and the authors of science textbooks tend to forget that they are "natives" in the language of science, whereas their students are not [28]. This causes many problems and challenges. For example, the language used in science classrooms differs greatly from the language students are used to [23]. This difference is one of the biggest reasons why students feel that reading science texts is difficult. For many students, the biggest problem in learning science is learning the language of science [29]. It is important to embed students in the language of science with guidance so that they get used to scientific terms and the use of the language [28].

One of the biggest challenges in learning the language of science is learning the science lexicon [23]. When studying science, one must learn a new lexicon (consisting of specific words, terms and concepts) and understand, for example, new phenomena by using the new lexicon. This is a double challenge when compared to learning a foreign language. The language of science is dense in information because it usually consists of scientific terms. These, sometimes very technical, terms are important in science because they enable exact descriptions of phenomena and their relationships. Clauses in scientific texts can be very long and have many nouns. Every noun adds to the amount of information in the clause, but in everyday language, one might use many different clauses to explain a similar kind of situation.

1.3. Network Analysis in Investigating Students' Use of Science Concepts

Nowadays, networks and graph theory are applied increasingly often to data analysis in fields where network representation is not an obvious way to analyze data [30]. A recent research paper utilizing a network approach to lexical networks has discussed the importance of extensive lexicons (or vocabularies) when gaining scientific knowledge. An extent lexicon can be regarded as a prerequisite to mastering scientific language and, thus, the ability to use it [31,32].

To sum up, the learning of science concepts and contents poses serious challenges for university students. For investigating this via the verbal outputs of students, we need sophisticated methodological tools. This study contributes to developing new modern methods to investigate this topic by exploring the written answers given by first-year life science students for tasks related to the role of photosynthesizing plants in the ecosystem from the viewpoints of food chains and the atmosphere, utilizing a modern network analysis method. To be precise, we investigate:

(1) Which (macro-)concepts and words do the students use when answering verbally certain questions concerning the role of plants in the ecosystem?

(2) How are the concepts and terms interrelated in students' verbal outputs?

2. Materials and Methods

2.1. Participants

The participants comprised 150 first-year life science students from the Faculty of Biological and Environmental Sciences (127 = females; 23 = males) from the University of Helsinki. A total of 56 students had biology as their main subject, while 48 students studied molecular biosciences and 46 studied environmental sciences as their main subject. The participants' ages ranged between 19 and 64, being on average 22.41 years old (SD: 5.17).

The study was performed according to the ethical instructions of the Finnish National Board on Research Integrity (TENK). The participants gave their permission, i.e., filled in the voluntary informed consent form. Participation in the study was voluntary, and the students had the possibility of withdrawing from the research at any time, without any consequences.

2.2. Measures and Data Collection

The topic was chosen because photosynthesis is one of the most central concepts in biology, forming the basis for all the energy sources essential to life, from the intake of food to the burning of fossil fuels [33,34]. Photosynthesizing plants also play a very important role in regulating climatic conditions, as photosynthesis controls the budgets of atmospheric gases, such as carbon dioxide. All in all, in this era of climatic, environmental and societal changes, a profound understanding of such a fundamental process as photosynthesis is a necessity for life science students. However, the role of plants in the ecosystem is also often underestimated among scientists, in the well-investigated phenomenon known as 'plant blindness' [35].

Therefore, two open-ended questions that required the application of basic conceptual knowledge were used as measures in this study. The tasks and the instruction were to: "(A) Explain the role of plants in the ecosystem from the food chains point of view"; and "(B) Explain the role of plants in the ecosystem from the viewpoint of the composition of the atmosphere." The tasks required understanding of basic biological phenomena, the most important being photosynthesis. In the curriculum of Finnish upper secondary education, the content of photosynthesis and the role of the phenomenon on a larger scale, including also the perspectives of climate change and energy flow and the cycling of matter in the ecosystem, are handled extensively.

The successful answering of question A required the student to understand that photosynthesizing plants are photoautotrophs and producers of the food chain, transforming solar energy to chemical energy that flows through the food chain for heterotrophs to consume. Additionally, plants play a role in material cycling in the ecosystem. A successful answer for question B required the student to understand that photosynthesizing plants regulate the gas balance of the atmosphere by absorbing carbon dioxide from the atmosphere and releasing oxygen. An increased amount of carbon dioxide in the atmosphere, caused as a result of human activities, is the main reason for the current changes in climate.

A model answer for task A, formulated by two biology university lecturers (with macro-concepts bolded and the contexts relevant for the analysis numbered in parentheses):

Explain the role of plants in the ecosystem from the food chain point of view.

> *The plants capture the light* ***energy*** *of the Sun and convert it to chemical energy for other organisms of food chains to use, and this process is called* ***photosynthesis*** *(C3). Autotrophic plants produce their own* ***nourishment****, unlike animals (C1). Therefore, photosynthesizing plants are* ***producers*** *of the food chain (C2). However, only a small amount of energy is transmitted to the next trophy level of the food chain.* ***Energy bypass*** *occurs because each trophy level uses energy to carry out their own life processes and functions (C5). Plants also play a role in material cycling in the ecosystem (C4). All in all, plants play a crucial role in the ecosystem from the* ***sustainability*** *point of view (C6).*

A model answer for task B, formulated by two biology university lecturers (with macro-concepts bolded and the contexts relevant for the analysis numbered in parentheses):

Explain the role of plants in the ecosystem from the viewpoint of the composition of the atmosphere.

> *In **photosynthesis**, the plants absorb carbon dioxide from the atmosphere and release oxygen (C1). Thus, as a result of photosynthesis, the **gas balance** in the atmosphere is favorable and stable, which has enabled current modes of life to evolve (C2). Plants also play a role in material cycling in the **ecosystem** (C3). Carbon dioxide is a **greenhouse gas,** the increase of which is a reason for ongoing **climate change** (C4). Thus, plants and, particularly, forests are **carbon sinks** that are important for ecosystems from a **sustainability** perspective.*

The lengths of the answers for the two questions were both restricted to six lines. Students gave their answers individually in a regular lecture hall context in September 2019, and they had approximately 30 min to complete the tasks.

2.3. Data Analysis

The lexical networks to be analyzed here were constructed from students' written answers, and such so-called lexicons play a key role in analyzing how students use different concepts and words in their answers [31,32,36]. To construct a stratified lexical network, a text analysis of students' written answers is performed, based on a grammatical sentence analysis in which special attention is paid to nouns and verbs, while the text analysis itself concentrates only on grammar and syntax. First, written answers were modified into simple sentences. In the simplification process, subordinate clauses are transformed into main clauses. Second, nouns are recognized, and the root verb is identified for each main clause. Third, the sentences are classified into contexts that are defined based on the model answers of university lecturers and students' answers (Appendix A). If a certain sentence was a mixture of more than one context, the decision of context was made based on the dominance or the precedence of the content. This means that if it was possible to identify the most emphasized aspect of the sentence, that ruled the context. In cases where the contexts were equally stressed, the first aspect within a sentence ruled the context where the sentence would be categorized. This was not common among answers since most of the sentences belonged clearly to only one context. Therefore, such choices do not greatly affect the results. The lexical analysis of the answers, and especially the decisions regarding which context the answers belong to, was carried out by two experts who followed a detailed analysis protocol. The interrater agreement of the context classifications was 69.9% for task A and 79.3% for task B. The simplified text structure was then transformed into lexical networks, where tag word nodes are connected to root verb nodes, and root verbs are connected to contexts. A more detailed description of the method is provided in Appendix B.

To construct the lexicon, we have first constructed a tiered lexical network, reflecting the position of a noun in either the clause, sentence or context. These constructs are not discussed in detail here because they are used only as auxiliary representations to quantify the lexical distance (for details, see [31,32]). The lexical distance of the terms and words in the lexical network is next quantified by using a so-called communicability centrality (more briefly, communicability in what follows) of nodes in the lexical network. Communicability describes the lexical support that the node (q) receives from other nodes. A pair of nodes that have high mutual communicability are close in the sense that they can easily reach (communicate with) each other, while those with low communicability are distant and cannot reach (communicate with) each other easily. Communicability is a global centrality measure characterizing the position of a node in a network. Moreover, as its name suggests, it is designed to describe how nodes can communicate or, alternatively, how the information content of a node can be passed to other nodes in the network (for the basic theory and construction of communicability measures, see, e.g., [37], for applications in lexical networks, see [31]). The computation of communicability as used here is explained

in more detail in Appendix B, closely following the steps as presented elsewhere in more detail [31,32].

The communicability between words is great in two obvious cases: first, when the given words (p) and (q) occur often in the same sentence; second, when many paths, even long ones, connect the words through a connection at deeper semantic levels. In both cases, one should take the word to have an important position in the network. The lexical networks are pruned by removing auxiliary and loosely connected words. The nodes that have low values of communicability are loosely connected within the network of connected terms and are thus auxiliary. By removing those nodes that fall below a prescribed threshold (in practice, having only a relative value of 0.30 of the maximal values of communicability of the most well-connected nodes) we create a lexical proximity network (LPN) retaining only the best-connected nodes. This lexical proximity network, which is a pruned version of the full lexical network, is called the lexicon.

The lexicon defined in this manner contains a summary of the information about the connections that students explicated in their answers about the role of plants in the ecosystem. A representation of the lexical information is produced from the lexical networks, in order to find out which terms play an important role in students' answers. It should be noted that here, the "importance" of a term means that it should have a key role in the totality of the answer, as part of an explanatory sentence or context-related set of sentences. Terms and words that are only listed in passing are dropped as auxiliary, unconnected terms. Obviously, by listing words, students show that they know the words, but the written answers do not reveal the way they use the words in an explanatory sentence or sentences as being central or important. Therefore, simply listing words is not counted in the present analysis as a sign of their importance.

3. Results

3.1. Concepts and Terms in Students' Written Answers

The first research question aimed to find out which concepts first-year life science students use in their answers when considering the role of photosynthesizing plants in the ecosystem from the food chain point of view (task A) and from the viewpoint of the composition of the atmosphere (task B). The frequencies of use for concepts and words are presented in Tables 1 and 2. The tables show that the most common concepts are clearly distinguishable and, respectively, a great number of concepts are mentioned only a few times.

In task A, the most common concepts, "the plant" and "food chain", were mentioned in the task instruction. The most frequent concepts introduced by the students were "energy", "producer", "organism" and "nourishment", most of which can be classified as macro-concepts related to the phenomenon of photosynthesis. These concepts are relevant in explaining the role of plants as primary producers in the biosphere. The occurrences of the concept of photosynthesis are relatively few in number. Furthermore, certain central concepts, such as "the Sun" or "light energy", associated with the origin of energy received relatively few mentions. Even fewer concepts related to the idea of the bypass of energy from the food chains were mentioned in the task for measuring students' understanding of the role of the plants from the point of view of the food chain.

Significantly fewer concepts and words were used in task B compared to task A. In task B, the most common concepts used were "the plant" and "the atmosphere", both mentioned in the assignment instruction. The concepts of "oxygen" and "carbon dioxide", initially presented by the students, occurred frequently. Macro-concepts, such as "photosynthesis" and "carbon sink", were mentioned, but not very often. The concept of "greenhouse gas" existed to some extent, but other related concepts, such as "climate change" and "greenhouse effect", were not mentioned in most of the answers.

Table 1. The frequency of concepts and words that the students used in their answers for task A (including terms mentioned at least seven times).

Concept/Word	Frequency	Concept/Word	Frequency	Concept/Word	Frequency
plant *	286	**organic**	22	link	11
food chain *	130	the second	19	usable	8
energy	127	important	19	carbon dioxide	8
producer	110	large	19	carbon	8
organism	81	form	19	nutrition	8
nourishment	66	trophy level	16	aid	8
consumer	51	role *	16	heterotrophic	8
ecosystem *	34	decomposer	16	food source	8
autotrophic	33	dependent	15	step	7
the first	32	oxygen	15	carnivore	7
biomass	30	substance	15	life	7
Sun	29	inorganic	14	animal	7
grade	28	solar energy	13	energy source	7
herbivore	25	sugar	13	primary production	7
glucose	32	**photosynthesis**	11		

Macro-concepts are bolded. * = this concept was mentioned in the task instruction.

Table 2. The frequency of concepts and words that students used in their answers for task B.

Concept/Word	Frequency	Concept/Word	Frequency
plant *	232	concentration of carbon dioxide	15
atmosphere *	197	concentration of oxygen	14
oxygen	172	**climate**	12
carbon dioxide	162	carbon assimilation	11
photosynthesis	41	greenhouse gas	11
organism	40	water	9
carbon	33	nitrogen	9
composition *	30	side product	9
carbon sink	29	role *	9
air	25	concentration	9
cell respiration	22	circulation	8
life	17	photosynthesizing	7
globe	16		

Macro-concepts are bolded. * = this concept was mentioned in the task instruction.

3.2. Network of Concepts

Our second aim was to investigate students' understanding related to the role of plants in the ecosystem by exploring their conceptual networks more profoundly. This was achieved by utilizing the network approach to describe the proximity of key terms in students' lexicons. Communicability measures, which describe the number of different routes between concepts, were calculated for all concepts. A concept that has a higher communicability ranking (see Tables 3 and 4) compared to its frequency ranking (see Tables 1 and 2) is globally more important. For example, the macro-concept of energy gets a higher importance value in this inspection, indicating that the concept was central to students' answers. On the other hand, the difference between tasks A and B becomes even clearer in this inspection, and in task B, the number of concepts is even lower when we explored communicability rankings compared to the occurrence frequency of concepts.

Table 3. Normalized communicability ranking of concepts and words that students used in task A.

Concept/Word	Comm.	Concept/Word	Comm.	Concept/Word	Comm.
plant *	1.000	**inorganic**	0.427	structure	0.290
energy	0.856	carbon	0.424	water	0.289
organism	0.829	compound	0.419	life process	0.287
food chain *	0.801	**heterotrophy**	0.415	life	0.270
nourishment	0.778	chemical	0.408	carnivore	0.245
producer	0.670	source of nourishment	0.393	**carbon assimilation**	0.244
consumer	0.655	**heterotroph**	0.389	terrestrial ecosystem	0.224
the first	0.625	species	0.389	soil	0.218
organic	0.606	herbivorous animal	0.364	**metabolism**	0.216
biomass	0.591	nature	0.362	light	0.201
ecosystem *	0.579	primary production	0.358	element	0.200
trophy level	0.566	**self-sufficient**	0.347	ground	0.200
living organism	0.552	food web	0.339	process	0.179
animal	0.551	sunlight	0.336	atmosphere	0.171
the second	0.545	alga	0.335	**autotrophic**	0.158
herbivore	0.531	nutrient	0.317	herbivore	0.152
sugar	0.522	**cell respiration**	0.300	diversity	0.147
glucose	0.516	**photosynthesis**	0.299	circulation	0.129
Sun	0.490	substance	0.295	molecule	0.127
decomposer	0.479	increase	0.295	Earth	0.093
predator	0.456	carbon dioxide	0.293	bypass	0.044
autotrophy	0.445	oxygen	0.291	insect	0.023
				food substance	0.000

Macro-concepts are with background colour. * = this concept was mentioned in the task instruction.

Table 4. Normalized communicability ranking of concepts and words that students used in task B.

Concept/Word	Comm.
plant *	1.000
carbon dioxide	0.848
oxygen	0.837
carbon	0.570
ecosystem *	0.245
life	0.228
biomass	0.214
glucose	0.206
producer	0.180
organic	0.085
Sun	0.000

Macro-concepts are with background colour. * = this concept was mentioned in the task instruction.

The conceptual proximity networks that were constructed, based on the communicability rankings of concepts for tasks A and B, are shown in Figure 1. These networks show only those concepts and terms that are connected to each other. The proximity network shows whether there are connections between concepts with many different routes. In Figure 1, we have drawn logarithmic values for communicability rankings in a diagrammatic form, in order to make the exponential values easier to compare with each other. Concepts that have only one connection to another concept drop out as unconnected concepts. This means that merely listing words is not counted as a sign of their importance.

This inspection reveals that the networks related to tasks A and B differed significantly. In task A, the conceptual proximity network was richer and included qualitatively different types of concepts compared to task B. In task A, the core layer of the conceptual network consisted of macro-concepts (e.g., energy, nourishment), whereas, in task B, the concepts that were found to be connected were mainly factual, such as chemical compounds (oxygen, carbon, carbon dioxide). In general, students' answers for task B remained at a more superficial level.

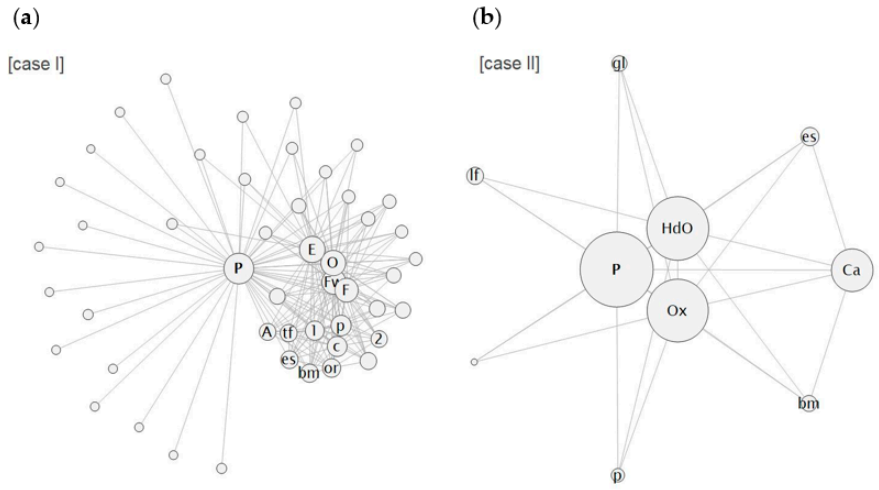

Figure 1. Left side (**a**), task A: Explain the role of plants in the ecosystem from the viewpoint of the composition of the atmosphere. P = plant; F = nourishment; E = energy; Fw = food chain; O = organism; p = producer; c = consumer; or = organic; 1 = the first; 2 = the second; bm = biomass; tf = trophy level; es = ecosystem; A = animal. Right side (**b**), task B: Explain the role of plants in the ecosystem from the food chains point of view. P = plant; Ox = oxygen; Ca = carbon; HdO = carbon dioxide; es = ecosystem; bm = biomass; p = producer; lf = life; gl = glucose.

4. Discussion

The purpose of this study was to investigate the incidence and interrelations of concepts in the verbal answers of first-year life science students concerning central biological contents, namely the role of photosynthesizing plants in the ecosystem, from the viewpoints of nourishment supply and the atmosphere. Students' written answers were investigated utilizing a specific conceptual network tool developed by the second and third authors of this article [31,32]. The analysis allows the exploring of both quantitative aspects (frequencies of terms used) and the interrelations between used terms (communicability). Based on previous studies, analysis of the extent of lexicons is a suitable qualitative method to evaluate students' level and quality of knowledge [cf. 31].

First-year life science university students are expected to construct an adequate conceptual knowledge base related to complex science phenomena, and simultaneously learn to use science language appropriately when communicating regarding science with teachers and peers. However, according to extensive previous research findings, this poses serious challenges for many university students [17]. Considering that a more integrated knowledge base at the beginning of university studies strongly predicts students' learning and achievement during further academic studies [38–40], a better understanding of the topic is important.

The results of this study showed that in the task measuring students' understanding of the role of plants from the food chain and nourishment supply perspective, the students used macro-concepts, such as "energy" and "producer", more than they used macro-concepts in their answers concerning the role of plants in the composition of the atmosphere. In the latter task, the students mainly operated with more superficial concepts, such as chemical compounds. Even though an understanding of chemical compounds is also indisputably important in biosciences, they are not considered as central macro-concepts in this context. In addition, although the assignment instructed students to consider the phenomena of photosynthesis and cell respiration on a global scale, certain central concepts that were present in the model answers of university teachers, such as "energy bypass", "climate change" and "greenhouse effect" were not mentioned in the answers of the students. These concepts connect the basic phenomenon of photosynthesis to current ecological challenges on a larger scale that, in twenty-first-century science learning, is

increasingly important [36,41]. The result is in line with previous findings that university students often struggle with applying basic knowledge [10,42].

Furthermore, it became apparent that the concept networks were remarkably richer and included more links between the concepts when it came to the students' understanding of the role of photosynthesizing plants in the ecosystem from the food chain point of view, compared with their answers related to the role of photosynthesizing plants from the point of view of the atmosphere. Thus, students' understanding related to the role of plants in the constituents of the atmosphere was more superficial compared to their understanding of food chains and nourishment supply. Generally, the existence of macro-concepts seemed to be related to richer and higher-level answers, whereas the lack of macro-concepts was related to more superficial answers. This finding is in line with the idea that the development of macro-concepts shows a move toward more abstracted and integrated concepts in denser knowledge structures, allowing so-called systemic understanding [10,43].

The first academic year is characterized as a strong predictor of future academic performance and achievement [44,45], which highlights the importance of timely support for new students to appropriately develop their science understanding and skills early on. This requires university teachers as well as students to become aware of differences between everyday language and scientific language, particularly in terms of science concepts. Furthermore, supporting students to learn to meaningfully use the language of science and to focus on interrelated concepts and contents, instead of unconnected facts, in science classrooms would promote the high-level learning of complex scientific phenomena.

Due to the characteristics of scientific language [23], students may have difficulties in writing down the answers to given tasks because they are not familiar with using the language of science. Knowing these characteristics of scientific language develops gradually in the course of further university studies. Compared to texts that students are used to reading and writing, the characteristics of scientific language together make scientific texts dense, abstruse, and hard to read and write [23]. This can often lead to the student reproducing isolated facts instead of constructing a rich and flexible conceptual network. Knowing the characteristics of scientific language might help students to better understand the language of science. In addition, the learning of scientific language becomes even more difficult if students must learn science in a foreign language instead of in their mother tongue.

In general, the students' answers for open-ended tasks in this study were scanty, which may reflect prevailing practices that students assume to be the desired answering style. It has been stated that science textbooks often present scientific models as if readers have no prior knowledge or have only relevant prior knowledge about the topic to be learned [46,47]. Furthermore, biological processes are often presented separately in textbooks, which may hinder the construction of interrelations between the concepts [48]. Even though it has been recognized that when learning science, fostering students' skills in conceptual understanding, problem-solving and scientific thinking are valuable objectives in creating a comprehensive understanding of the given subject (see, e.g., [49]), very little attention is paid to the coherence and cohesion of written tasks. An important question for future research is how study programs in higher education can build on these observations to support students in constructing a solid and well-organized knowledge base.

The following aspects need to be considered when generalizing the results outlined in this paper. Firstly, the majority of the participants in this study were female students, which is typical of the population from which this sample was drawn (i.e., majors in biology, environmental sciences and molecular biosciences). Additionally, in this study, the answering space for open-ended tasks was restricted via lines that might have influenced the answering style into being more compact and list-like than it would have been without restriction.

Furthermore, the representations of linguistic networks depend strongly on the text on which they are based, and the decisions when forming contexts also have a great impact

on forming the linguistic network. In a linguistic network, there is a connection between two words if they appear often in the same context. However, the definition of contexts determines what counts as a connection in a linguistic network. The research objectives guide that definition and, therefore, different research setups can result in very different linguistic networks, even from the same data. In this sample, the connections between concepts are formed through single sentences. This means that there are no connections between sentences, i.e., text cohesion is missing in the students' answers, or this method is not able to identify it.

5. Conclusions

Learning scientific knowledge, especially counterintuitive concepts regarding phenomena of the physical and biological world, is hard and, typically, it requires a considerable restructuring of students' initial knowledge. Furthermore, university students are required not only to learn new science knowledge but also new competencies in order to use the language of science appropriately. The results of this study indicate that network analysis method provides important insights into life science students' understanding, and their abilities to operate with science language related to complex environmental and socio-economic phenomena. In addition, the results show that in science classrooms, paying attention to students' conceptions of the basic science phenomena that underlie current sustainability challenges is relevant. For example, understanding the role of photosynthesizing plants, which forms the basis for all the energy sources essential to life and regulating the budgets of atmospheric gases, e.g., carbon dioxide, is needed in order to understand the current climate crisis and the questions related to nourishment production for a growing population. Future science experts are today's university students, who will need to be equipped with a high level of scientific knowledge and reasoning skills to solve complex and unforeseen serious problems. The results presented in this article can hopefully inspire further research and serve to guide university science educators in supporting students' systemic understanding in biology classrooms.

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Institutional Review Board Statement: Voluntary participation, informed consent, and anonymity of the participants were ensured in the research process. The study did not involve intervention in the physical integrity of the participants, deviation from informed consent, studying children under the age of 15 without parental consent, exposure to exceptionally strong stimuli, causing long-term mental harm beyond the risks of daily life, or risking participants' security (cf. Finnish Advisory Board on Research Integrity 2019). Consequently, this study did not require a Finnish ethics review.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Appendix A

Contexts in task A: "Explain the role of plants in the ecosystem from the food chain point of view".

Context 1—Self-sufficiency of photosynthesizing plants:

C1 Produce their own nourishment.

Context 2—The role of plants as producers in the ecosystem.

C1 Convert solar energy to chemical energy.
C2 Produce nourishment and O_2.
C3 Role as primary producer/the first link in the food chain.
C4 Other organisms are dependent on them.

Context 3—The role of plants in energy flow in the food chain:

C1 Sunlight as the origin of the energy.
C2 The plants enable energy transmission in the food chain, from herbivores to carnivores and decomposers.

Context 4—The role of plants in the cycling of matter in the ecosystem:

C1 Circulation of nutrients.
C2 Circulation of water.
C3 Circulation of O_2.

Context 5—Bypass of energy in the food chain:

C1 Only a modest part of the solar energy is used in the photosynthesis process.
C2 Most of the photosynthesized energy is used by the organism's own metabolism.

Context 6—The role of plants from the point of view of the sustainability of the ecosystem:

C1 Produce/store CO_2.
C2 Release O_2.
C3 The plants as carbon sinks/"lungs of the earth".

Contexts in task B: "Explain the role of plants in the ecosystem from the viewpoint of composition of the atmosphere".

Context 1—The role of plants as the regulator of optimal atmospheric composition:

C1 Gas exchange: photosynthesizing plants bind CO_2 and produce O_2.
C2 The role of plants as "lungs of the earth".
C3 The role of plants as carbon sinks.
C4 The role of plants from the atmospheric humidity perspective.
C5 O_2 plays a role in O_3 formation.

Context 2—The role of plants in the origin of current life:

C1 Due to photosynthesizing plants, the O_2 and CO_2 levels of the atmosphere are suitable for current life modes.
C2 Without photosynthesizing plants, the atmospheric level of O_2 would be higher and the level of CO_2 would be higher.
C3 A suitable atmospheric level of O_2 is a prerequisite for organisms.
C4 Cell respiration: CO_2 and O_2 enable respiration.

Context 3—The role of plants in the cycling of matter:

C1 The plants absorb and transpire water.
C2 As the plant dies, the substances from it get released back into the soil.
C3 The plants play a role in the cycling of carbon/oxygen and nitrogen.

Context 4—The role of plants from the climate change perspective:

C1 A high atmospheric level of CO_2 has a heating effect on the planet.
C2 Current climate change/global warming may at first accelerate the growth of global vegetation.

C3 A decrease of living plant biomass leads to the acceleration of global warming.
C4 Plants' increased ability to absorb CO_2 helps mitigate climate change/global warming.

Context 5—The role of plants considered without appropriate connection to the task:

C1 Cell respiration: the plants' respiration releases CO_2.
C2 The plants produce glucose/energy/biomass.
C3 Description of the consequences of global warming.
C4 The role of other photosynthesizing organisms except for plants.

Appendix B

Method

The lexical (or conceptual) networks are built here on the basis of how often the same words and terms occur at different levels, from the syntactic level (clauses) to the semantic level (contexts). Such connections form a stratified lexical network that bears information of the lexical distance of terms at different levels of syntax (for details, see [31,32]).

The method to quantify the connectivity between terms in the lexical network is based on a measure called communicability centrality [37] that pays attention to the different contiguous paths found between nodes (terms) in the lexical network. The paths can be weighted according to their lengths. The counting of such paths is used to measure lexical proximity. This measure tells how a node can pass information to other nodes through the network.

A lexical network that has N nodes can have (at most) $N \times (N-1)$ different links between the nodes (terms). We can describe such a network by using adjacency matrix $\mathbf{A}$, in which elements $[\mathbf{A}]_{pq} = a_{pq}$ have a value of 1 if there is a connection between nodes p and q, and a value of 0 if the nodes are not connected. We can use adjacency matrix $\mathbf{A}$ to calculate the number of different paths between two nodes in the lexical network.

The number of long paths increases almost factorially in a well-connected network. Therefore, we are interested in the relative weight of these paths, and the solution is to divide the number of walks by the factorial. This is called the communicability measure [37]:

$$G_{pq}(\beta) = \frac{1}{1!}\beta^1\left[\mathbf{A}^1\right]_{pq} + \frac{1}{2!}\beta^2\left[\mathbf{A}^2\right]_{pq} + \frac{1}{3!}\beta^3\left[\mathbf{A}^3\right]_{pq} + \ldots = \left[e^{\beta\mathbf{A}} - \mathbf{1}\right]_{pq}$$

where e[...] is the matrix exponential, **1** the identity matrix, and [...]$_{pq}$ is its element at row p and column q. Note that here, a slightly modified version of the standard definition of communicability [37] is used for convenience. The communicability has a free parameter $\beta \geq 1$. Parameter β adjusts how wide the part of the network we look at should be when counting the paths. The optimal value for parameter β offers the best diversity of terms at the lowest possible value of β. The optimal value seems here to be about β =1.

We can construct a lexical proximity network of key words and terms, where terms and words are linked according to their lexical distances. This modified and pruned lexical network, which contains only those terms and words that are connected well enough (exceeding a given threshold of proximity), is called a lexicon.

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Article

Drawing Skills of Candidates for Architectural Studies vs. Learning Outcomes of Graduates. Comparative Research Based on the Example of The Faculty of Architecture, Poznan University of Technology

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Abstract: Major changes in the organisation of the teaching process at universities in Poland had to be introduced in response to the current pandemic situation and threat of further spread of SARS-CoV-2 virus. This article presents the results of the research conducted at the Faculty of Architecture, Poznan University of Technology in view of the pilot, experimental entrance exam that excludes the evaluation of drawing skills of candidates for architectural studies in the 2020/21 recruitment process. The purpose of the research was to find a correlation between the quality of candidates accepted for the BSc (engineer) programme studies, evaluated on the basis of their drawing skills demonstrated during the entrance exam and the learning outcomes of graduates. For that purpose, the authors hereof have carried out an analysis with the use of the Spearman Rank Correlation formula. The comparative analysis has shown that candidates whose drawing skills were evaluated highly during the entrance exam did not necessarily rank as the top grade scoring graduates of the first degree study programme, and thus, it has further been shown that good drawing skills at the beginning of the study programme do not guarantee top learning results at the end of the studies. In effect, the research should become a starting point for a discussion in Poland on whether there are any justified grounds for entrance exams in drawing or whether a portfolio of works may replace it and be an effective recruitment criterion.

Keywords: architectural education; architectural studies; admission exam in drawing; higher education; drawing

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1. Introduction

Instruction on drawing and design skills constitutes the most important part of architectural education [1]. The global research conducted so far on architectural education, including the applicable recruitment criteria, shows a wide range of used criteria, which among others, include: evaluation of portfolio of works, results of secondary school leaving exams (A-levels and O-levels) and interviews or exams in drawing. According to the research, there is not one, uniform recruitment procedure [2]. All of the applied criteria are intended to verify the suitability of candidates in view of successful completion of the study programme and pursuit of professional career. It is certainly worth attempting to systematise the applicable recruitment criteria and requirements at the regional, national, and international levels [1]. Other studies also show that admission requirements posed for candidates show a weak correlation with the students' performance during their studies. This means that students that ranked at low positions during the recruitment process may still score high study grades if they commit themselves to studying diligently.

At the same time, too-high requirements posed for the candidates may not result in the increased efficiency of learning outcomes and may only limit access to architectural studies [3]. Moreover, it must be remembered that architectural education should be integrated

with technological progress and innovative tools in architectural design on a continuous basis [4]. On the one hand, it might be concluded that the days of manual drawings are gone, but it is in fact to the contrary, mainly for the reason that manual drawings show individual features of their authors whereas digital computer visualisations of architectural designs will be based on standardised software options. Individual expression predetermines the superior and iconic value of the drawing [5]. Moreover, it is not just a method of vision or design presentation but is also a design method itself [6]. Architectural education in Poland is strongly dependent on applicable provisions of law. Architectural education is offered within study programmes of architecture or architecture and urban planning, with core courses in architecture and urban planning. Study programmes can be offered by state-run universities and private schools of higher education and can be taught in full-time and part-time form of a general academic or vocational profile. Moreover, study programmes may be taught as uniform (MSc) programmes or the first and the second cycle of studies (with the award of the degree of an engineer or master, respectively). However, regardless of the options described above, all study programmes are developed based on applicable laws, and in particular on the Law 2.0 [7], the Regulation of the Minister of Science and Higher Education on architectural education standards and other standards [8]. The provisions set forth for the duration of the study programme (number of semesters), the minimum number of hours of instruction and the minimum number of ECTS points required to be scored by the student in the course of the studies; in this, the score of students' drawing skills are evaluated within the fine arts classes. The Regulation in detail prescribes the core subjects or groups of subjects that are mandatory for architectural education to be taught within groups of subjects A–E:

A. Design, including: A.1. Architectural design and urban planning and A.2. Rural design, interior design and special design customised to local conditions
B. Designing context, including: B.1. Theory and history of architecture and urban planning, landscape architecture, heritage protection, cultural studies, environmental protection and ecology, economics of an investment process, law in the investment process and ergonomics; B.2. Engineering and technology: construction and materials technology, building structures, statics and mechanics of civil engineering structures, physics of constructions, building systems and town infrastructure; and B.3. Workshop design: drawing, painting, workshop techniques, computer techniques, modelling, mathematics and geometry.
C. Supplementary subjects, in particular: foreign languages and electives such as philosophy and aesthetics, history of art, environmental sociology and psychology
D. Practical placements
E. Diploma: preparation for the submission of diploma thesis and taking the diploma exam.

Apart from requirements in the scope of groups of subjects, the legal provisions also set forth the number of hours of a practical placement each student has to complete during their studies. Nevertheless, the applicable laws fail to prescribe any uniform evaluation criteria for the positive qualification of drawing skills of candidates for the first cycle study programs or uniform M.Sc study programmes in the field of architecture. This means that university authorities in Poland enjoy discretionary powers in defining the admission criteria to architectural study programmes.

At present, the majority of state-run universities in Poland hold mandatory entrance exams for candidates for the study programmes of architecture or architecture and urban planning. These exams partly include a practical part, i.e., a drawing exam, and partly take into account grades the candidates scored in selected subjects in their secondary school exit exams. Such a procedure is applied at faculties of architecture in leading Polish universities (Unieversities of Technology in Gdańsk, Kraków, Wrocław or Warsaw) as well as in smaller university centres, such as Lublin or Łódź. Some private universities, including SSW in Sopot or Vistula Business Academy, departed from the evaluation of candidates' drawing skills some time ago.

Thus, a drawing exam is a regular part of the recruitment process in Poland and a condition precedent for admission to studies at various state-run universities. However, it has to be acknowledged that some students can draw well without any prior training, and some would require instruction to be able to draw well [9].

The issue of drawing skills of candidates for architectural studies is widely discussed both by academics and by researchers. Interdisciplinary qualitative and quantitative studies are conducted of which the purpose is to improve the quality of tertiary education and that of the graduates. The results of education are compared in terms of measurable parameters, including the number of candidates, admission exam grades and final grades. The necessity of such research is explained by what is expected from the graduates of architectural studies. After the period of fascination with computer-aided methods of design visualization, the job market tends to look for candidates with manual skills quite often. Conceptual designs are presented in the form of manual drawings and sketches.

The role of manual drawing in architectural education is fundamental and indisputable; thus, drawing is included in the mandatory core subjects of architectural study programmes in Poland [10]. Despite the rapid development of digital tools used in architectural design, such tools cannot replace manual drawing either in architectural education or at any stage of a professional career, yet they should be mastered by the future architects alongside the manual drawing skills in the process of their education [1]. Even if, initially, the rapid progress of digitalization of the design process and the application of specialized software seemed to be forcing manual skills out, this has not happened. The key role of manual drawing as a method of teaching consists not only in the representation of reality but also in its transformation based on the individual experience and know-how. This makes manual drawing a fundamental element of architectural education. It is not an objective in itself but rather a method of communication used by all designers [6]. It is, however, vital to fully integrate both tools as supporting the superior role of the drawing as such in the process of visual design and in education [11].

The present research was conducted at the Faculty of Architecture, Poznan University of Technology. The Faculty of Architecture, Poznan University of Technology, is a recognised unit of architectural education in Poland. It has been ranked as one of the leading universities and was awarded with the best quality assurance in 2018 in the field of architecture by the Polish Accreditation Committee (PAC). Moreover, it has been accredited by the Accreditation Commission of Universities of Technology (KAUT) and awarded with the European Eur-ace Label quality certificate. In 2017, the Faculty received an A category in the parametric evaluation of scientific units of the KEJN (Committee for the Evaluation of Scientific Units). Being a leading and highly recognised institution, it has decided to introduce a pilot solution. At present, there are almost 1000 Polish and foreign students at the Faculty. The study programme is offered in Polish and in English. Every year, 180 Polish and foreign students are admitted to the first year of studies in the field of architecture at the Faculty of Architecture. At the same time, the number of candidates usually exceeds the number of accepted students by three times and ranges from 500 to 600. Moreover, it has been regularly showing an increasing trend. In the academic year 2017/18, the number of candidates was 636, in the academic year 2018/19—2014648 and in the academic year 2019/20—580.

The entrance exam is composed of two drawing sessions, which take place within the premises of the university and comply with the most stringent confidentiality standards (works coding) and verification standards (verification of identity of candidates); the exam procedure is observed at the exam organisation by the Faculty Recruitment Committee and supervised by the Dean. The drawing sessions are supervised and recorded. Works are evaluated by two independently working committee teams. Such organisation ensures that the faculty meets the high standards of the recruitment and evaluation procedure.

Pencil technique is always used. Students draw on a white paper 100 $\times$ 70 in vertical orientation. The topics of examination drawing session are diverse, ranging from imagination (draw a city of the future) to drawing from nature (draw a still life or a model).

The committee evaluates work taking into account composition, proportions, spatial relations, principles of perspective, properties of objects and the use of chiaroscuro. Works are evaluated in the 2.0–5.0 scale (every 0.25).

At present, due to the COVID-19 pandemic, by the virtue of the decision of the Ministry, all forms of full-time study programmes have been suspended at universities and schools of higher education in Poland, and the organisation of the above described recruitment procedure is not permitted due to the fact that proper safety needs to be ensured for the candidates and academics to protect them against the virus.

For that reason, exam procedures applicable in the recruitment for architectural studies at renowned European universities, the authors hereof have evaluated the performance of the graduates (overall grade of studies) in the field of architecture with their results scored at the entrance exam before their admission. The research aimed to answer the question whether there was any correlation between the quality of the candidate (his/her drawing skills) at the beginning of architectural education and their learning results in the course of studies and upon the completion of studies.

2. Materials and Methods

The research was conducted on a sample group of graduates of the faculty of architecture—BSc (Engineer) programme (the first cycle programme) in the field of architecture, who completed their studies in the period from 2018 to 2020. In total, 360 graduates were analysed (108 of the 2018 graduates, 114 of the 2019 graduates and 138 of the 2020 graduates).

The grade scored by the candidate (quality of the candidate) was compared to the overall grade of studies of the graduates (quality of the graduate), taking into account the then applicable principles of recruitment.

The entrance exam for candidates for architectural studies is composed of two stages:

- The grades the candidates scored in selected subjects in their secondary school exit exams (maximum allocated points—500) (M);
- the drawing exam (maximum allocated points—500) (R).

First, the quality of the candidate expressed by the number of points allocated to him/her at the entrance exam was compared to the quality of the graduate of the first cycle programme in the field of architecture expressed with the average studies grade converted into relevant number of points. The purpose of such a comparison was to find a correlation between the entrance exam results and the final result at the completion of the BSc (engineer) study programme, and in particular to learn whether top ranks at the entrance exam (M+R) translate into high performance (quality) of the graduate (architect, Eng.). The authors in particular wished to analyse the final, overall studies grade in view of partial results of the entrance exam, i.e., points allocated for the grades in the secondary school leaving exams (M) and points allocated for the drawing stage (R). For that purpose, the Spearman Rank Correlation formula is used: nonparametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale (Figure 1a–c). A candidate's drawing skills were evaluated by the grade obtained in the recruitment process in the 2–5 scale (translated for recruitment purposes into the scoring scale of 0–500 points). In addition, the results obtained by graduates of architectural studies are marked in the 2–5 scale. On each graph, graduation years are colour-coded (2018—red, 2019—blue, 2020—black).

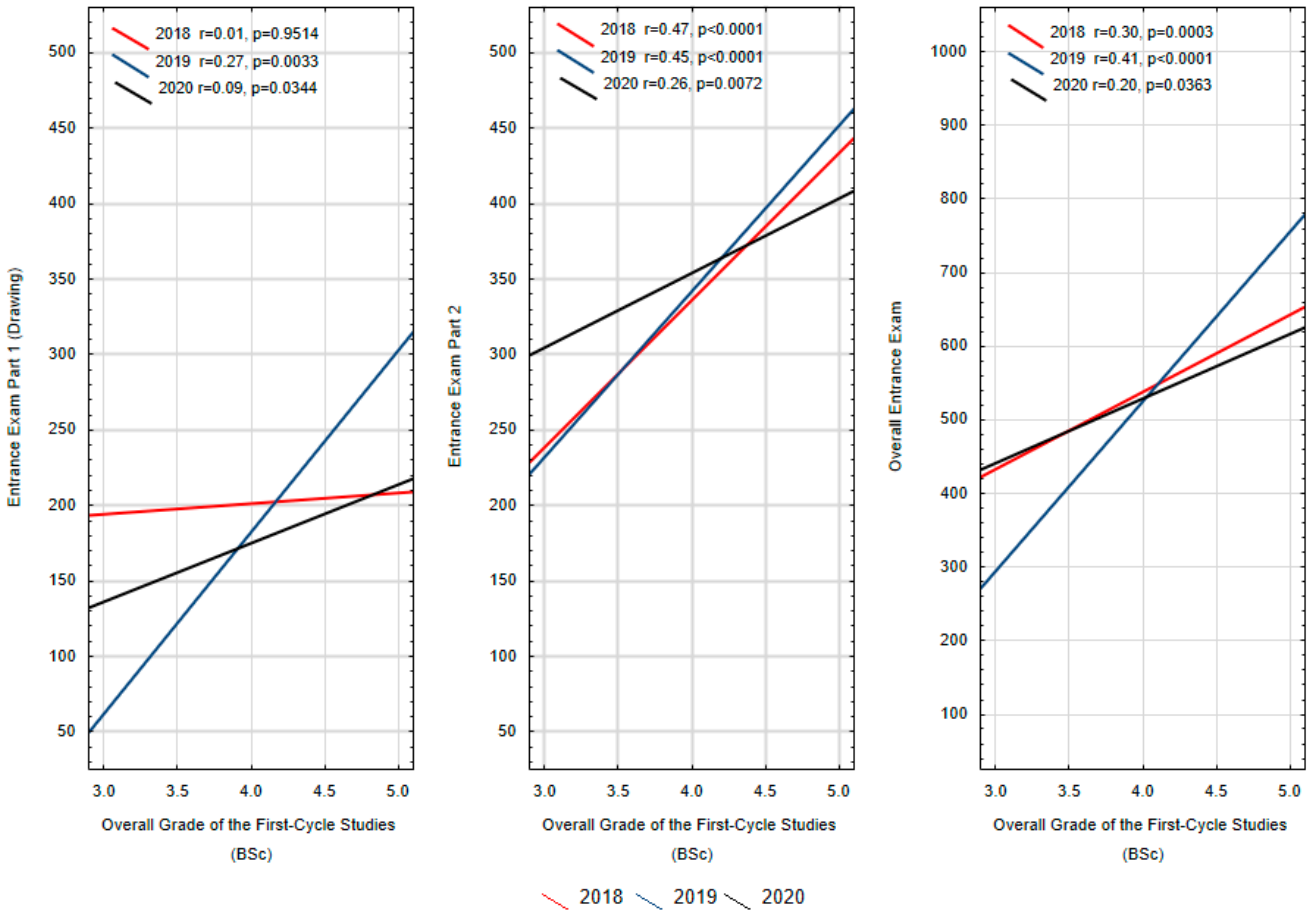

Figure 1. (**a**) dependence between the entrance exam (R) and quality of the graduate, (**b**) dependence between the entrance exam (M) and quality of the graduate, (**c**) dependence between the entrance exam (R+M) and quality of the graduate.

The analyses were made separately for the 2018 graduates, the 2019 graduates and the 2020 graduates. The analysis measured the correlation between the quality of the graduates of architectural studies (first cycle programme) and three variables:

- drawing skills before the commencement of studies expressed as the number of points allocated in the drawing stage of the entrance exam (R) (see Figure 1a);
- points allocated for results of the secondary school leaving exams (M) (see Figure 1b);
- total number of points scored in the entrance exam (M+R) (see Figure 1c).

In Figure 1, the horizontal axis shows final study results in the 3 to 5 scale, while the vertical axis shows:

- in Figure 1a—result of entrance examination in drawing (part 1);
- in Figure 1b—result based on the candidate's secondary school matura result (part 2);
- in Figure 1c—total entrance examination result.

The correlation is depicted by lines created by a cloud of dots (the number of dots equals the number of candidates).

Next, at the second stage of the research, statistical analysis was conducted to learn whether there is any correlation between rank of the candidate in the entrance exam and his/her performance in the subsequent years of studies during the first cycle programme and his/her learning outcomes in artistic subjects.

For that purpose, the entrance exam score in drawing was compared to all the grades a given candidate obtained in artistic subjects during the overall study programme, i.e.,

in the "Drawing" course in semester 1, 2, 3 and 4 (see Figure 2a–d)) during the first two years of studies. The Spearman Rank Correlation formula was used again.

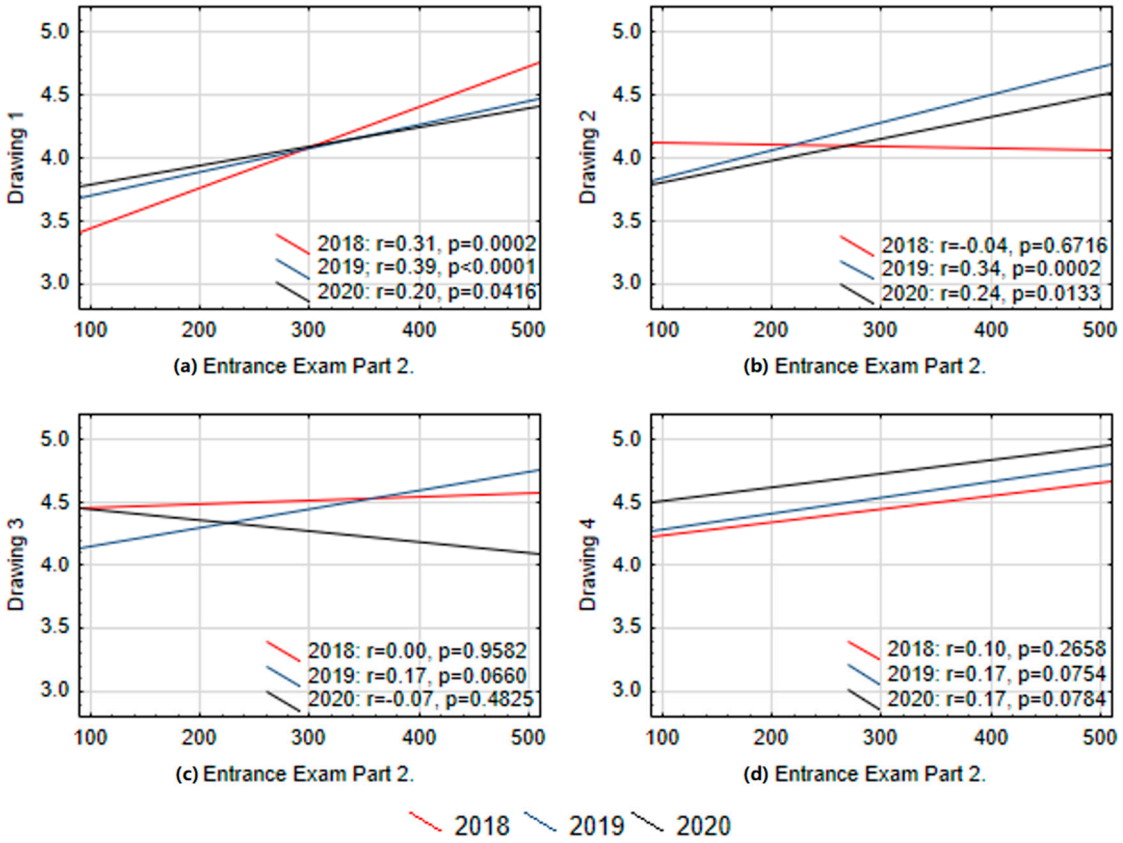

Figure 2. (**a**) dependence between results scored upon completion of semester 1 and the entrance exam (R), (**b**) dependence between results scored upon completion of semester 2 and the entrance exam (R), (**c**) dependence between results scored upon completion of semester 3 and the entrance exam (R), (**d**) dependence between results scored upon completion of semester 4 and the entrance exam (R).

This method was used to find the correlation between candidates' drawing skills at the beginning of their architectural education, evaluated in the recruitment procedure at the entrance exam and their performance during the first two years of studies in the artistic subjects based on their progressing drawing skills.

A candidate's drawing skills are marked with the use of a grading scale from 2 to 5 (translated for recruitment purposes into the scoring scale from 0 to 500). In the course of the study, student drawing skills are marked with semester grades from 2 to 5.

In Figure 2a–d, the horizontal axis marks entrance examination results and the vertical axis results obtained in drawing classes in particular semesters. Again, the correlation is shown by lines made of the dot cloud and the number of dots equals the number of graduates included in our study.

Figures 3–5 visually show the correlation between the quality of the graduates of architectural studies (first cycle programme) and drawing skills before the commencement of studies expressed as the number of points allocated in the drawing stage of the entrance exam (R).

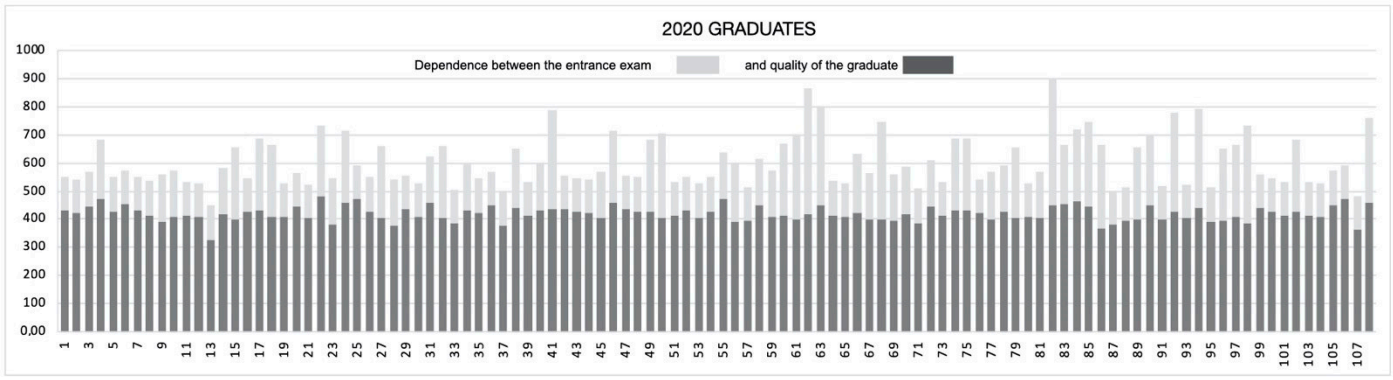

Figure 3. The ranking of 2020 BSc (Engineer) programme graduates vs. their position on the admission list (result of entrance exams in drawing).

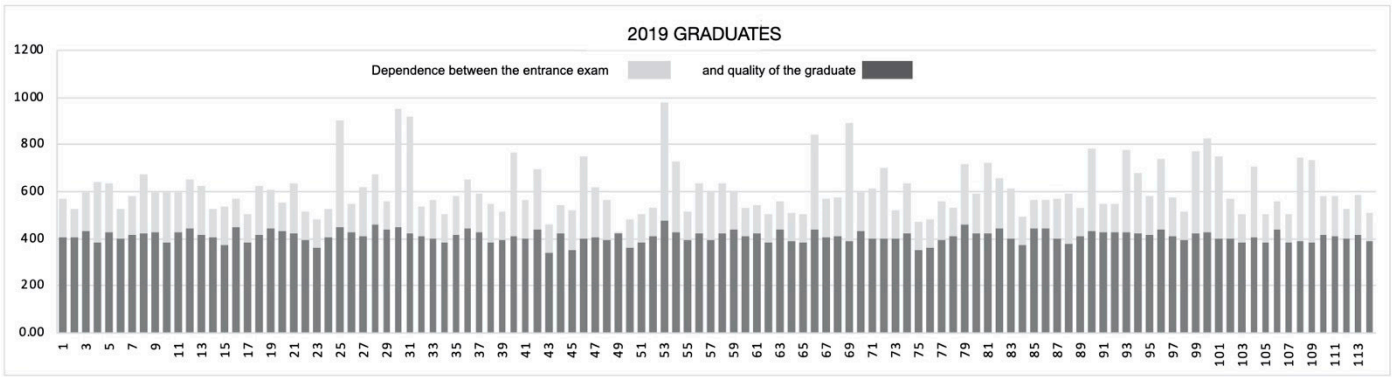

Figure 4. The ranking of 2019 BSc (Engineer) programme graduates vs. their position on the admission list (result of entrance exams in drawing).

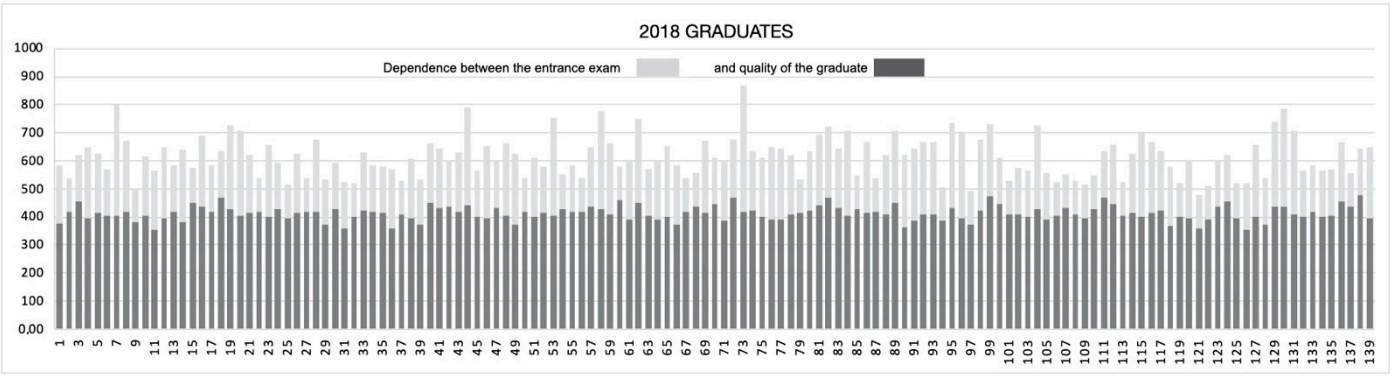

Figure 5. The ranking of 2018 BSc (Engineer) programme graduates vs. their position on the admission list (result of entrance exams in drawing).

3. Results

Having completed the first analysis of the correlation between the learning outcomes of graduates and the quality of the candidate, it has been found that the correlation between the top results of the entrance exam (M + R) in the field of architecture and the overall study grades upon their completion was moderate. Moreover, the correlation was the lowest when the learning outcomes of graduates was compared to the results of the drawing stage of the entrance exam. The mean coefficient of the Spearman Rank Correlation was r = below 0.03 (i.e., R = 0.01 for the 2018 graduates, 0.27 for the 2019 graduates and r = 0.09

for the 2020 graduates); thus, the correlation between the 2018 and 2020 graduates was low and that with the 2019 graduates was poor. The analysis of the results confirms that the verification of the drawing skills at the recruitment stage does not translate into a high score at the completion of the first cycle of architectural (engineer) studies.

An inverse relationship was found as regards the correlation between quality of the candidate measured with the results of the secondary school leaving exams (M) at the entrance exam, and the graduate performance. Here, the correlation is high. The mean coefficient of the Spearman Rank Correlation was over 0.4 (0.47 for the 2018 graduates, 0.46 for the 2019 graduates). Only in the case of the 2020 graduates was the coefficient a bit lower, 0.26 (low correlation, i.e., correlation present)

This shows that the results of the secondary school leaving exams (M) scored by candidates for architectural studies are much more important, as regards their contribution to the quality of the graduates, than the results scored by them in the drawing exam. This means that drawing skills verified in the recruitment process do not determine the quality of graduates of master engineer studies in the field of architecture.

The second analysis was intended to find the correlation between the results scored at the entrance exam (drawing stage) and the grades scored by the students in respective semesters of studies in artistic subjects, i.e., Drawing 1, Drawing 2, Drawing 3 and Drawing 4. Such present correlation was found only as regards the students' performance in the first two semesters of studies. The mean coefficient of the Spearman Rank Correlation was $r = 0.3$ after the first semester.

In subsequent semesters, i.e., Drawing 3 and Drawing 4, the results obtained in the entrance exam (the drawing stage) failed to be reflected in the learning outcomes and grades scored in artistic subjects. The mean coefficient of the Spearman Rank Correlation was $r = 0.11$ for the last two semesters of the drawing instruction.

This shows that there is no correlation between the results obtained in the entrance exam (the drawing stage) and the grades obtained by the students in the Drawing classes during their education in subsequent semesters of studies (this concerns the artistic subjects: Drawing 1, Drawing 2, Drawing 3 and Drawing 4).

At the same time, these findings enable us to state that drawing skills can be effectively improved in the process of architectural education. The studies also show that the results of drawing exams have a significant impact on the ranking of university candidates. If, for some reason, the 2020, 2019 and 2018 graduates had not been required to pass an exam in drawing and had been admitted merely based on their grades scored in secondary school leaving exams, then some 30% of the candidates would not have been admitted at all, after being ranked below the admission limit. Instead, those candidates with better grades in secondary school leaving exams and worse drawing skills would have been admitted. The impact of the admission requirements and the entrance exam in drawing on the quality of the students of architectural studies is assessed to be 1/3.

4. Discussion

The organisation of the drawing exam is a logistics challenge because the number of candidates for architectural studies is constantly increasing.

Assessment of the drawing skills is important in view of the fact that it is closely correlated with other skills of the students, e.g., writing skills. Students who show better drawing skills usually do better in textual exercises [9].

Having analysed the obtained results, in particular the dependencies between the results of the entrance exam (drawing stage) and the learning outcomes scored at the first cycle programme of the architectural studies (quality of the graduate), it has been concluded that the drawing skills that the candidates have before the commencement of architectural education are only of secondary importance for their overall learning outcomes in the entire period of studies. It may be further concluded that the high qualifications of the academics and the high quality of the architectural education programme guarantee top learning outcomes in artistic subjects. Thus, students that did not do so well at their entrance exam

in drawing and ranked low at the admission list can easily make up for their poor drawing skills and graduate from studies with a high overall study grades, anyway.

In Poland, the recruitment procedure for architectural studies in the majority of universities includes a mandatory drawing exam organised in a stationary form to verify the drawing skills of the candidates. The research conducted by the authors is of a pioneering nature and the results thereof lead us to conclude that the criteria applicable during the recruitment procedure at architectural studies fail to be based on justified grounds. Therefore, it seems fully justified to continue to research this issue further by extending the sample group with graduates that completed their studies earlier than the group researched herein in order to form a relevant standing in view of the requirements of the recruitment procedure.

The presented studies attempt to assess the impact of the recruitment procedure on the quality of graduates from architectural study programmes taught at state-run universities in Poland, and to compare the situation in Poland with the learning outcomes of graduates of renowned European universities, e.g., the University of Technology in Milan, where the recruitment procedure does not include any verification of the drawing skills of the candidates.

As other researchers claim [12–14], a higher admission point threshold and stringent admission criteria do not always signify the efficiency of the education process itself and may often limit access to architectural studies. One should also note that, currently, the recruitment procedures used in renowned European university centres offering architectural education differ. To study architecture in the UK, a candidate is supposed to submit a letter of motivation, references and a portfolio and go through an interview. Recruitment is often carried out in several stages. The number of works in a portfolio and their topics often differ from university to university. Basically, there is no examination in drawing; the evaluation basis is the portfolio, and the entire recruitment process may be completed online. The portfolio is quite extensive, often containing 20–30 drawings that are presented electronically (as pdf or jpeg files). This makes British universities definitely more accessible than Polish ones. In Italy, universities such as Politecnico di Milano or Rome University do not verify drawing skills but require candidates to pass an examination checking general knowledge in such areas as history, art, mathematics and physics. In Germany, the situation is different: a portfolio is mandatory, just as it is in Holland and France. When we look at Polish conditions, on one hand, they are more uniform but, on the other, they are also stricter, as personal presence at the exam is required and online submission is not permitted. This is definitely another element that prevents Polish universities to open up to foreign students.

On the basis of the results presented herein, the Faculty of Architecture, Poznan University of Technology, decided to exclude the drawing exam from the recruitment criteria. The 2020/21 recruitment procedure was solely based on the grades the candidates scored in their secondary school exit exams. Deviation from the previously adopted form of the drawing exam for candidates for architectural studies directly stemmed from the situation of a global pandemic, which prevented the organisation of the exam in the previously applied stationary form. Nevertheless, as indicated above, this shall not entail a lower quality of the graduates of architectural studies in Poland, nor shall it be reflected directly in the performance of the students in the artistic subjects.

At the same time, it shall only confirm the justified grounds for the recruitment criteria that apply in many other European universities in reference to admission to architectural studies, which do not verify in any way the drawing skills of candidates because they can acquire such skills in the process of their architectural education. Instead of a drawing exam, many of the European universities include a presentation of a portfolio of works and deem it an adequate and sufficient recruitment criterion. The next planned step is to supplement this research by evaluating the careers of architecture graduates in Poland and correlating their professional position after studies with their skills at the beginning and end of their studies. Such research will offer a greater understanding of the role of

architectural drawing in architectural education in Poland, as a wider practical context will be taken into consideration, i.e., the professional aspect.

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education sciences

MDPI

Article

STEM Faculty Instructional Data-Use Practices: Informing Teaching Practice and Students' Reflection on Students' Learning

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Abstract: This paper explores the affordances and constraints of STEM faculty members' instructional data-use practices and how they engage students (or not) in reflection around their own learning data. We found faculty used a wide variety of instructional data-use practices. We also found several constraints that influenced their instructional data-use practices, including perceived lack of time, standardized curriculum and assessments predetermined in scope and sequence, and a perceived lack of confidence and competence in their instructional data-use practices. Novel findings include faculty descriptions of instructional technology that afforded them access to immediate and nuanced instructional data. However, faculty described limited use of instructional data that engaged students in reflecting on their own learning data. We consider implications for faculty's instructional data-use practices on departmental and institutional policies and procedures, professional development experts, and for faculty themselves.

Keywords: STEM; undergraduates; instructional data; teaching practices; instructional technology; assessment; student reflection on learning; policy

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1. Introduction

1.1. Calls for Increasing Instructional Data-Use Practices in Postsecondary Education

In response to calls for increased accountability from policymakers, accreditation agencies, and other stakeholders, higher education institutions are devoting more resources to gathering and analyzing evidence around student learning outcomes to inform strategies promoting student success and persistence [1–3]. Specifically, educators are asked to gather and respond to evidence of student learning to inform their future teaching-related decisions and practices. These calls, including for those faculty working in the STEM disciplines (science, technology, engineering, and mathematics), demonstrate a growing focus for many concerned with improvements to postsecondary education [4,5]. This push is well founded. Educators' systematic use of instruction-related data has been shown to enhance student learning and achievement via faculty data-driven decisions [6].

The push for faculty to engage in systematic instructional data-use practices goes beyond their summative examination of students, often infrequent and not particularly illuminative [1,5], to include more formative data-use practices, including those that can inform immediate teaching practices. These connote increased repertoires of practice for many faculty, placing additional demands on them and, by association, those who seek to help develop their teaching-related practices. Emerging research indicates that STEM faculty are not necessarily ready to utilize diverse instructional data effectively or to constructively inform practice generally [5]. Teaching improvement interventions that target STEM faculty development of effective instructional data-use practices are becoming more numerous [1,4]. However, alongside limited knowledge about how postsecondary educators make decisions about their teaching overall [7], we still know little about how

instructional data informs faculty teaching-related decisions [5,8]. This lack of knowledge limits abilities to help faculty enhance their instructional data-use practices, meet the calls of those calling for this, and respond to faculty members' actual realities and needs.

What we do know from the research around educators' instructional data-use practices largely concerns the degree to which K-12 educators implement policies mandating these practices [9,10]. A growing body of practice-based research investigates the experiences of K-12 educators' agency and capability to employ data-use interventions in light of their professional contexts, e.g., [10–12]. From this research, we have some insight into why and how instructional data-use interventions are effective (or not). For instance, we know that educators must find instructional data relevant and meaningful concerning their teaching realities to consider changing their teaching practices in light of it [10]. In addition, we know that K-12 educators appreciate talking with other educators about data, including how to interpret it in light of practice [12]. Furthermore, educators' data use happens in light of larger contextual complexities. Institutional norms and structures, including departmental and social networks, can influence educators' access to and practices around data, including the knowledge and skills they need to analyze and use data to improve instruction [12–14]. Research in K-12 educators' successful interventions that target educator's data-use practices can lead to meaningful and more reliable assessments of students' learning [15].

1.2. What We Know About Postsecondary Faculty's Instructional Data-Use Practices

While the above K-12-focused research provides some important insights, we need empirical evidence that examines how postsecondary educators use instructional data [4]. Limited empirical research indicates that most postsecondary educators may not consider collecting and reflecting on instructional data to be their responsibility [16]. In addition, faculty may not have access to meaningful instructional data that they feel can inform their teaching [16], including those in the STEM disciplines [4,8]. Faculty also may not feel confident or competent in analyzing instructional data [3,17]. They may not have adequate time or appropriate resources or tools to engage in data-driven decision-making concerning instructional practices [5,18].

Even those postsecondary educators trained in STEM disciplines, where effective data collection skills and use may be assumed, have shown more limited instructional data use, even when data were made available to them. In one study, Bouwma-Gearhart and Hora and colleagues [4,5,8] explored the instructional data-use practices of 59 STEM faculty and 20 administrators at three institutions. Faculty noted they collected instructional data due to accreditation requirements and policies related to departmental reviews, but less so as part of their other instructional decision-making processes. Departmental and institutional interventions designed to improve faculty use of instructional data had low impact due to limits to faculty time and their lack of expertise with using teaching-related data. Notably, faculty found the availability of instructional data experts at their institutions to be an affordance, such as other faculty and staff, sometimes located in centers for teaching and learning. Faculty were more likely to implement instructional data-use practices and types of data if they aligned with their overall instructional goals. They generally found institutionally collected data, such as student evaluations, to be unreliable and insufficient, which discouraged their use of this data and provided motivation to create and implement some other instructional data practices. Although many faculty did not implement many instructional data-use practices, they found that those who did across their wide sample used various instructional data-use practices, both quantitative and qualitative. Decisions regarding data analysis that applied to practice included altering future versions of the courses based on analysis of exams and altering the pace of teaching, including time spent on particular topics.

While the above studies are helpful in understanding faculty use of instructional data, we need additional research to confirm or test these limited findings. Much of the scholarship related to arguments for the use by postsecondary educators of instruction-

related data is anecdotal with limited empirical rooting [1]. What we do know about these faculty members comes from one study of STEM faculty from three universities, i.e., [4,5,8]. Specifically, we need additional inquiry about faculty realities that may drive interventions, development, and implementation to serve as affordances for what happens when faculty interact with data in their work [12]. Additionally, while instructional technologies hold the promise of influencing faculty's collection and use of data and the ability to involve students more in the learning process, we largely lack evidence of this promise for these educators. Further, given the increased recognition of the value of involving students in reflecting on their learning, more research is needed on how STEM faculty can foster and engage students in reflecting on data around their learning [19,20]. Knowledge of these phenomena can assist in designing effective supports for faculty to more frequently and better use instructional data to improve their teaching and student learning, ultimately translating into greater success for students [21].

1.3. Instructional Technology That Influences Instructional Data-Use Practices

One affordance championed for faculty collection and instructional data-use practices is instructional technologies (e.g., electronic learning platforms and their analytics tools). Behind the push for faculty to use these tools are assumptions around the easy and quick collection and basic analyses of learning-related data they can provide [22]. Studies suggest faculty adoption and use of instructional technologies is slow and inconsistent [23]. In a report, Lester et al. [24] state much of the research around instructional technologies focuses on the different types of technology tools that faculty and institutions may use (e.g., clickers, learning management systems, adaptive learning). This research includes how technologies are adopted and adapted by institutions and their use and perceived usefulness by students of these tools. Lester and colleagues also state a paucity of research on faculty pedagogical changes resulting from using instructional technologies. However, they suggest insights gained from research around individual faculty decisions to incorporate other innovations into their teaching practices can inform faculty use of instructional technology. Specifically, they cited research that has identified faculty identity and beliefs established through disciplinary socialization and behaviors that can affect decision-making, e.g., [23,25,26].

Although instructional technologies may be appreciated by faculty as a potential means to improve teaching and learning, other studies found that many instructional technologies were not used to their fullest potential. Klein et al. [27], in a study of 6 faculty and 21 advising staff, identified barriers to effective use included a lack of reliable data infrastructure that was deemed cumbersome and misaligned with user needs as a deterrent to technology use. In another study, Hora and Holden [23] interviewed and observed 40 faculty in STEM departments at 3 universities in the U.S. Not surprisingly, perhaps, they found that faculty use of instructional technologies largely depended on its availability (or not). They also found faculty use turned on faculty perceptions of relevance to and alignment with their pre-existing beliefs and instruction goals, meaning faculty needed to see the instructional tool supporting their pedagogical practices. They also found that faculty members' prior experiences with the technology and the perceived affordance of particular tools influenced their use. These studies suggest that faculty use of instructional technologies, and the promise of such for their instructional data use practices, may be more complex than just access to technology. Still, more research is needed in this area to confirm or challenge these limited findings and provide insight into how faculty use instructional technology to inform decisions related to their teaching practices.

1.4. Instructional Data-Use Practices That Involve Students Reflecting on Their Learning

Calls for research investigating instructional data-use practices that involve students reflecting on their own learning-related data are growing as faculty are encouraged to shift their instructional practices from teacher-centered to more learner-centered approaches [16]. Faculty must shift their thinking from seeing their role, primarily, as a transmitter of knowledge to one that empowers students in their own learning and provides students more

meaningful feedback around their learning, beyond only results of summative assessments and final grades [21,28,29]. Ryan and Ryan [30] assert that including students in reflecting on their learning data is more than just sharing grades or exams with them. They state that students reflecting on their learning have generally included having students complete structured and unstructured reflective journaling, formal reflective papers, interviewing, and group memory work. Ryan and Ryan acknowledge the value of these activities but contend that examples of faculty engaging their students in systematic and deliberate activities that involve reflective learning are rare. The researchers noted potential barriers that influence faculty engagement of students in reflecting on their learning, including factors related to students' socio-cognitive abilities. These factors include students' developmental stages, such as whether they were in their first year or a later year of study in the discipline or field of study. The faculty's use of reflective practices was also influenced by the context and potential complexity of the discipline in which the learning occurred. A final factor that may influence faculty when engaging students in reflective learning is the diversity of learners who bring prior knowledge, abilities, and experiences that may add to the challenges faculty may encounter when engaging students in reflective learning practices [30].

Indeed, the faculty's use of instructional activities that have students reflecting on their learning data has been shown to foster student learning of course content and instill a greater sense of accountability for their learning [21]. Some research results seem promising, demonstrating that some STEM faculty are meeting researchers' calls to engage students in reflecting on their learning-related data (e.g., [20]). Nonetheless, more research is needed that investigates how faculty use their instructional data to design activities that engage students more in reflecting on their data.

1.5. Paper Focus

This paper details an exploratory study conducted at one U.S. research university of STEM faculty members' instructional data-use practices. Specific findings confirm the work of Bouwma-Gearhart and Hora et al., including faculty constraints to their data-use practices such as lack of time needed to implement data-use practices, standardization of course content that constrained some types of data collection, and a perceived lack of confidence and competence in their instructional data-use practices [4,5]. Novel findings include faculty descriptions of instructional technologies that they claimed allowed more timely and complete data to respond to more immediately in practice. Faculty who used adaptive learning technologies specifically claimed it helped them collect more nuanced data on achievement trends for different groups of students. Although all faculty used summative data (i.e., exams, written assignments), several faculty described less reliance on these typical data indicators of student learning, rather using other practices such as group work to measure student learning. Faculty were mixed in their practice of engaging students in reflecting on their own learning data. These practices were generally described as activities in which students were asked to reflect on their overall performance in class and how their use of study techniques may (or not) be helping them. We discuss the affordances and constraints that faculty perceive in their instructional data-use practices. We also discuss implications for departmental and institutional leaders, faculty leaders, professional developers, and for faculty themselves.

2. Methodology

2.1. Conceptual Frameworks

We assume faculty work within "complex network[s] of structures, tasks, and traditions that create and facilitate practice" [31], p. 2, which Halverson terms *systems-of-practice*. Faculty encounter in their systems-of-practice structures such as procedural norms and policies, physical objects and tools, and activities that can serve as affordances and impediments to their work (see Figure 1). Perceived affordance theory [32,33] is also relevant to our study as it helps to explain how and which structures and activities are salient to

faculty and impact their practice. *Perceived affordances* are factors in the system that faculty sense and deem relevant around a task related to their self-perceived ability to attend to the task [33,34]. As examples, affordances can be structures or activities that educators believe will allow (or inspire) them to engage in collecting and using instructional data. For instance, educators may use instructional technologies, such as clickers, to collect certain types of instructional data of their interest, assuming they have some competency to use the tool.

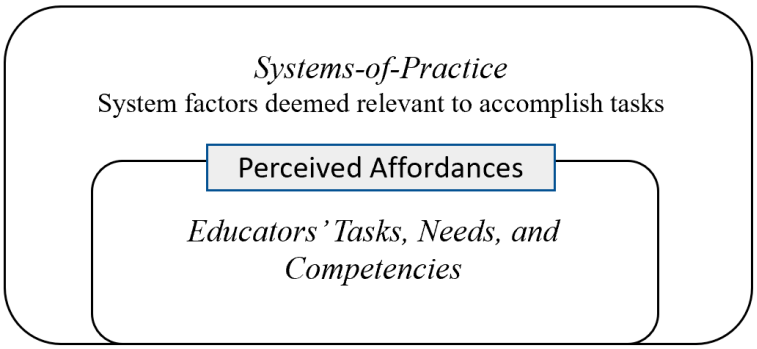

Figure 1. Conceptual Framework: Integrating Perceived Affordances [32,33] and System-of-Practice [31] Theories.

Affordance theory has been used by other researchers who recognize postsecondary educators as functioning within complex socio-cultural systems. Hora [35] found that structural and sociocultural factors afforded and constrained teaching practices. Affordances included the high degree of autonomy faculty had in making decisions related to their teaching practices. Constraints included policy implications related to issues such as promotion and tenure requirements. As demonstrated in some of this past research, affordances are not always positive for an educator's actions or insights [33]. Affordances may also be barriers to action [7]. For instance, Bouwma-Gearhart and colleagues found that frequent formative assessments that took up class time could act as barriers if faculty felt pressed to cover large quantities of specific types of content. We use perceived affordance theory to illuminate the realities of educators operating in complex socio-cultural systems in light of their professional realities, including their pedagogical knowledge, skills, norms, and felt competencies.

2.2. Research Questions

Our exploratory research is guided by the following questions:

1. What are the instructional data-use practices of a sample of STEM faculty from one U.S. research university and why?
2. What affordances and constraints, including instructional technologies, do these faculty claim regarding their instructional data-use practices?
3. To what extent do faculty engage students in reflecting on their own learning data?

2.3. Study Context

This study took place at one large university in the United States, classified in the Carnegie Classification of Institutions of Higher Education [36] as a "doctoral university with the highest research activity". A comprehensive (campus-wide) STEM education improvement initiative was underway to foster evidence-based instructional improvements in large-enrollment, lower-division STEM courses by leveraging the distributed expertise of faculty to learn from one another. Funded by the National Science Foundation, a project research goal was to investigate changing faculty perceptions of teaching and their teaching-related practices in light of the initiative activities. This paper centers around findings

from interview data collected near the end of the initiative, in 2017, specifically around the questions exploring faculty instructional data-use practices.

Participant Sample and Data Collection

Prior to collecting the interview data that roots this paper, surveys were sent to 420 faculty across STEM disciplines with 127 faculty responding, a 30% response rate. Table 1 shows the total number of survey respondents in each of the disciplines surveyed.

Table 1. Faculty respondents in STEM disciplines. N = 420 (n = respondents); Engineering includes civil, chemical, biological and mechanical.

Physics		Chemistry		Biology		Mathematics		Engineering		Total	
n	%	n	%	n	%	n	%	n	%	n	%
12	9	18	14	13	10	27	21	57	45	127	30

Quantitative survey data were collected to ascertain the influence of the initiative's various aspects and inform subsequent interview protocol development. While the survey and interviews, focused on various aspects of the teaching of interest to the larger NSF-funded project, this paper focuses solely on faculty experiences around instructional data use.

We used descriptive analysis from three survey questions to probe for faculty perceptions of the larger group regarding their gathering, analyzing, and responding to data that informed their teaching. Respondents indicated their level of agreement on a scale of 0 (Not true at all), 2 (Somewhat true), and 4 (Very true) to the following prompts:

1. I know how to gather, analyze, and respond to data that informs my teaching.
2. I regularly gather, analyze, and respond to data that informs my teaching.
3. I am committed to gathering, analyzing, and responding to data that informs my teaching.

When faculty were asked if they regularly gather, analyze, and respond to data that informs their teaching, the results of the 127 faculty surveyed were a mean score of 2.50 ("Somewhat true" on a 5-point scale; SD = 1.04). Faculty indicated a slightly higher mean of 2.74 ("Somewhat true"; SD = 1.02) when asked if they were committed to gathering, analyzing, and responding to data. Faculty indicated a mean score of 2.75 ("Somewhat true"; SD = 0.94) when asked whether they knew how to gather, analyze, and respond to data that informed their teaching (see Table 2). A standard deviation of approximately one showed a relatively uniform view of faculty perceptions regarding instructional data use.

Table 2. Faculty perceptions of gathering, analyzing, and responding to instructional data. [1] Variable mean coded on a 5-point scale of 0 = "Not true at all," 2 = "Somewhat true," 4 = "Very true" (n = 127).

Survey Item	*M* [1]	*SD*
I know how to gather, analyze, and respond to data that informs my teaching.	2.75	0.94
I regularly gather, analyze, and respond to data that informs my teaching.	2.50	1.04
I am committed to gathering, analyzing, and responding to data that informs my teaching.	2.74	1.02

These survey results prompted us to explore instructional data use in interviews to allow richer data around these issues. From those responding to the survey, invitations were sent to faculty across the represented disciplines to conduct interviews. Nineteen out of twenty-one faculty invitees consented to interviews (90% response rate). (See Appendix A for full interview protocol.) An external project evaluator conducted the semi-structured interviews, which lasted approximately one hour.

Table 3 shows disciplines, participant pseudonyms, and professional positions for the 19 STEM faculty who participated in the interviews for this study. Faculty disciplines included physics, biology, chemistry, mathematics, and engineering (chemical, biological,

environmental, and mechanical engineering). Nine of the faculty were in tenure-track faculty positions (assistant, associate, and full professor), and ten were in fixed-term faculty positions (instructor and senior instructor). Participants had taught at least one lower-division STEM course in the previous year and were involved in the campus initiative. Race/ethnicity and gender data were not collected in this study, and we do not want to make assumptions about participants' identities. We were further concerned with ensuring anonymity given the sample size, identification of disciplines, and professional positions of a group of faculty from just one university. Thus, we use pseudonyms that we perceive as gender-neutral.

Table 3. List of Disciplines, Participants' Pseudonyms, and Participants' Professional Positions. N = 19. Tenure-track faculty include assistant, associate, and full professors, Fixed-term faculty include instructors and senior instructors.

Discipline	Participant	Professional Position
Physics	Robin	Fixed-Term Faculty
	Jamie	Tenure-Track Faculty
Chemistry	Jordan	Fixed-Term Faculty
	Alex	Fixed-Term Faculty
	Sidney	Fixed-Term Faculty
	Casey	Fixed-Term Faculty
	Tracy	Tenure-Track Faculty
Biology	Jodi	Fixed-Term Faculty
	Peyton	Fixed-Term Faculty
Mathematics	Leslie	Tenure-Track Faculty
	Jackson	Fixed-Term Faculty
	Madison	Fixed-Term Faculty
	Kelly	Fixed-Term Faculty
	Drew	Tenure-Track Faculty
	Shannon	Tenure-Track Faculty
Engineering	Lee	Tenure-Track Faculty
	Bailey	Tenure-Track Faculty
	Logan	Tenure-Track Faculty
	Lynn	Tenure-Track Faculty

2.4. Data Analysis

Data analyzed from the interviews for this paper pertained to the following questions:

1. I'd like to hear more about your assessment practices while teaching.
   a. To what extent do you collect data/information about student learning?
   b. Are your teaching practices informed by data/information about student learning?
   c. Are there means in the classes/courses that you teach for students to reflect on their own learning data? (If yes), Can you detail these processes?

Interviews were transcribed verbatim and transferred to Dedoose coding software for qualitative analysis. The first author created inductive codes from a first read of the verbatim transcripts, drawing perspectives from interviewees' own words in response to interview questions [37]. We attempted to stay grounded in faculty descriptions and matching those with definitions of the concepts. During both rounds of coding and analysis, the first analyst created theoretical memos [38] to provide a record of developing ideas and interconnections.

We used several methods put forth by Creswell [39], pp. 201–202 to address our findings' trustworthiness. One method we used to ensure the trustworthiness of the analysis was peer debriefing. The second author supported the codes' development and participated in debriefing and data analysis sessions with the first author throughout the coding and analysis of the data. The second author also reviewed 20% of the coding to increase

reliability and consistency and provide ongoing contributions to the emerging codebook. (See Appendix B for codes.) In both phases, the authors discussed emerging concepts and themes based on their critical reflections on the data, and an ongoing discussion of codes and interpretations addressed (dis)agreements within the data [37]. At least two interviewees made all the claims we report in this paper. We included exact numbers of participants in conveying claims.

2.5. Limitations

We acknowledge the multiple limitations of our research. For one, our study took place at one institution with one improvement initiative targeting select STEM disciplines. Overall, our exploratory study is based on a small sample size, with some claims voiced by a few and, in some cases, two participants. As well, faculty who agreed to be interviewed may represent a biased sample of faculty who were engaged in making improvements via some affiliation with a campus-based improvement initiative, and thus, may not fully reflect the larger population of STEM faculty. Disciplinary norms and practices, which may influence faculty practices and perspectives, were also not explored per limited sample size. We did not collect observations of actual faculty data practices, including how faculty reacted to data or how types of data linked with any corresponding faculty actions across our sample. Finally, although we discuss our findings in light of past research around the effectiveness of types of data or faculty data-use practices, we did not collect data that would allow comment on effectiveness.

3. Results

3.1. Types of Instructional Data Faculty Collected

3.1.1. Summative Data-Use Practices

All faculty indicated that they collected summative data to inform them about their students' learning. Summative instructional data generally included a combination of mid-term and final exams, quizzes, and, to a lesser extent, written assignments. Typically, these assessments were quantitative (e.g., multiple-choice) if class sizes were large and generally administered two to three times during the term. A majority of faculty perceived summative evaluations as an effective measure of student learning and determinants of grades.

Robin (physics) indicated that 70% of their students' grades came from exams, including two exams around "mid-term" and a final course exam. They felt these types of assessments, and the data they generated, gave them the best opportunity to know what an individual student comprehended.

> *Let's start by saying roughly 70% of my student grades come from exams. There's two midterms, and a final and those are the best way that I know that student is presenting me the information that they personally know and they're not working with others.*

Alex, a chemistry instructor, described these summative data-use practices as "traditional," utilized, in part, because of the significant number of students in their classes. They described weekly individual quizzes, mid-term, and final exams consisting primarily of multiple-choice questions out of necessity, although they did have some open-ended questions on the exams.

> *We do very traditional assessments in a sense because, in the fall term, we have fourteen hundred students. We have ten weekly quizzes, and those are individual. We have ten small group activities, one per week. We have two midterm exams and a final consisting of a section of multiple-choice, which is out of practicality, and about forty percent of that exam is open-ended, so it's free-response for students.*

3.1.2. Perception of Changes to Summative Data Practices

While acknowledging the need for summative data-use practices, some faculty also signaled their data practices were shifting away from typical exams as the only determinant

of student learning to other means such as group exams. A few faculty (4) described how they felt relying only on summative data-use practices was problematic, per student diversity and in terms of data quality. Two faculty indicated concern that typical means of gathering summative data (e.g., exams) did not allow all students ample opportunities to show what they had learned and, thus, did not accurately reflect student progress. These faculty also felt typical exams did not provide them with sufficient data to determine students' course grades and sought to minimize the use of summative data-use practices as the primary determinant of these grades.

Tracy, a chemistry instructor, exemplified both of these findings. Tracy described a shift they had made away from exams as the sole determination of students' grades to a grading structure that allowed for over fifty percent of the final grade to be determined by students' work on papers, class presentations, and online work. Some of these activities involved group work. Nonetheless, they were considered a significant part of the grade students earned. Tracy discussed how they were deemphasizing formal exams and a desire to engage students more actively in the material. Tracy stated,

> *This year was a pretty dramatic change to over fifty percent of the grade, and the assessment was not exam-based. So the students were writing papers, which they got formative feedback on, and they were developing presentations that they gave in class and also published on the website where they also had some feedback and revision steps there. Teaching assistants were assigned to some of those activities, so they hopefully got some fairly frequent feedback. Most people were working in groups rather than individually on some of those assignments, sharing their results, presenting them, and all of that was pretty high stakes because the total for those activities like I said, was over half the grade. So we deemphasized formal exams, there were midterms and final exams, but they were lower stakes. That came out of both the desire to get students more actively engaged in the material. On the assessment end, I think we've recognized, I've seen over many years, that exams are great for many students, but I think they don't measure all student activity and success and learning.*

Tracy perceived that adding different student assessments to their teaching repertoire resulted in more traditional ones feeling like "lower stakes" for students.

3.1.3. Formative Data-Use Practices

Nine faculty (47%) described engaging in collecting formative instructional data, which they felt gave them immediate information about student learning. These included qualitative forms of data, either curricular artifacts or verbal information qualitatively gathered from students. Nine faculty (47%) described collecting this type of formative data, described as "submission sheets," "exit points," "muddiest points," or "Tuesday problem." These activities required students to evaluate or respond to a question or statement related to course content. These activities resulted in data artifacts that faculty stated informed them about their students, learning, and interests. These activities were often described as "low stakes" for students, supposedly concerning more typical assessments of their learning (e.g., formal exams).

Drew, a mathematics instructor, described using "exit cards" at the end of class to assess students' level of understanding or confusion. They allowed students to be anonymous in their submission. They described this activity as giving them a quick opportunity to see what students were learning and what might need to be addressed again. They said it in this way, indicating some benefit of the anonymous, low-states (not graded) nature of the activity for students.

> *In terms of formative assessment, I have used things like exit cards, where at the end of a class, I just have students [write down a question or comment]. There's no grade at all attached to this. It's just for me to get some sense of what did you [student] think was the most significant thing you learned today, what was the muddiest point. These kinds of quick questions that people jot down on a card and can even be anonymous, and then a*

> *quick look through all of that gives me a sense of, 'oh wow,' I really missed the boat here. I need to re-address that topic again.*

Lee, an engineering instructor, talked about using "muddiest point" activities that gave him information about topics that students wanted to know more about. Lee also perceived these formative assessments as providing him data about students' understanding of the concepts and via a low-stress activity to assess their level of understanding. Lee stated that the activity allowed insight into.

> *...whether they want more coverage on a specific subject. In terms of reflecting on their own performance, I certainly think that when you make an assignment like full credit for participation or sort of the check if they are there working and engaged, it also sends a message to them about how they engage in the material. Both of those were sort of meant to reward them for being there and engaging, but not making it so high stakes, so it wasn't supposed to be a stress out sort of thing.*

Lee also felt giving credit for these kinds of assignments sent a message to students about the importance of attendance and being engaged in the assignments. Like Drew, Lee discussed this being lower stakes for the students.

Lynn, another engineering instructor, described using an activity they called "the Tuesday problem." This activity would give students a problem to work on during a break during a class. After the break, they walked around to observe and help students who presented as needing extra attention. Like Drew and Lee, Lynn indicated this activity gave them an informal way to engage with students, resulting in a less stressful assessment activity for them. Lynn described it this way,

> *The Tuesday problem or something like this, where I take a break in a two-hour lecture, a ten-minute break, and I put up a problem, and I say you guys are welcome to solve it or not, but when we get back from the ten minutes I'll solve it, and then we'll talk about it, and you put it up, and you walk around, and you see if people are trying and you kind of help them, or you give them pointers on what direction to go. So there is a way to create way more informal engagement by doing things that way because there's very little stress because it doesn't count for any points, really.*

As Lynn also alluded to, faculty also detailed gathering verbal forms of data (i.e., talking with others) to provide them with information about their students' learning. Six faculty (32%) spoke of collecting instructional data through verbal interactions with students, usually informally, to gather information.

Jordan, a chemistry instructor, spoke about providing an open environment for students to discuss challenges and fears. They described how talking and interacting with students allowed them to "have a discussion about the growing pains of going through science education." Sidney (chemistry) said that informal interactions with students gave them some of the most valuable instructional data they collected. They describe how most of their assessments, depending on the course, were done through these informal, information-gathering interactions with students to determine if students liked the course or what parts they did not like.

> *Most of my assessment, and I think this is true for most people, comes from informal interactions. Of course, it depends on the course, but oftentimes I informally really try to just talk to students as much as I can and see how things are going. I often say, 'Hey, what do you like about the course? What don't you like?'—again, about as informal as could be, but I sometimes find those are most valuable.*

Another faculty, Bailey (engineering), similarly talked about informal interactions with students to gather information about their courses. They indicated using their office hours and visits from students to ask them questions about how they were feeling about the content that was being taught. They even probed via questions to students about whether students understood a particular concept that the instructor was trying to convey.

> *Then students in office hours, if they seem willing, I'll often ask how do you feel about this content area, or even more specific things like I tried to tell you this, did you notice that in class, or do I need to do that differently.*

Another faculty, Peyton (biology), talked about meeting with students frequently to assess what students were saying to understand where they were and where the instructor thought they ought to be. Peyton said,

> *I meet with my students a lot, so I hear what they're saying, and I use that to inform where they're at and where I think they need to be.*

Two faculty described how talking with their teaching or learning assistants provided them insight into student learning. In this excerpt, Robin (physics) described a learning assistant program they developed that allowed them another way to collect formative types of data on students. During weekly meetings, the learning assistants provide feedback to the instructor about students, including what they perceived to be working or not working. Robin said,

> *Qualitatively, I'm talking to my students constantly. I've developed a learning assistant program, so I have ten learning assistants, and they're constantly giving me feedback about what's working, what's not working, helping me try to guide the students. And I have seven T.A.'s [teaching assistants] at any given moment, and we also have meetings every week.*

Looking across these data, two main goals were apparent. Faculty collected instructional data to assign student grades and to assess learning. Some faculty recognized that certain summative data, from exams, was not adequately allowing for meaningful assessment and grading of students, thus motivating them to also collect other types of instruction-related data. Some faculty also went so far as to comment that data around student learning then allowed them to plan for future teaching (i.e., reteaching or teaching in a way that students most appreciated), to secure better student understanding or success. Faculty linked timely impact on teaching practices to formative forms of data.

3.2. Affordances That Influenced Instructional Data-Use Practices

3.2.1. Faculty and Organizational Student Assessment Norms

We also found several affordances that influenced the instructional data-use practices of faculty. Not surprisingly, they often pointed to data they collected that provided insight around their teaching as data types and means that were norms for them as practitioners and within their larger organizations. For example, more traditional types of student learning assessments (i.e., exams, written assignments) remained privileged by faculty and their departments. Thus, faculty kept using them and claimed to be informed of students' progress via them. Nevertheless, many faculty also claimed a desire for other data to inform them in ways that more traditional assessments did not. Narrative and verbal types of data, for some students, provided them novel data around students' understanding and provided them more timely feedback for more immediate response to students, like "submission sheets," "exit points," "muddiest points," or the "Tuesday problem" exercise. Generally, faculty relied on "tried and true" methods, like course exams, to gather summative, often quantitative data to inform their teaching. When they sought different or more complete information or to help students feel more comfortable and relaxed in providing them with information around their learning, some faculty gathered and utilized other data, namely formative and largely qualitative.

Learning and teaching assistants were another affordance that two faculty used to gather data on students' performance. As described by one faculty, the development of a learning assistant program afforded them feedback on what was working or not related to students' learning.

3.2.2. Instructional Technologies

Eleven faculty (58%) reported that instructional technologies afforded them opportunities to collect and analyze data to inform their teaching. These included audience response systems (i.e., clickers), online platforms for homework or other course materials, and adaptive learning technologies. Overall, faculty detailed these technologies in comparison to when they did not have them or had to rely on more traditional, or lower-tech data gathering means. The instructional technologies allowed more timely and complete data to respond to more immediately in practice.

Several faculty used clickers, which they claimed provided them in-the-moment snapshots of students' levels of understanding and the opportunity to correct student (mis)comprehensions. Peyton, a biology instructor, noted that if the class scored below 85% on the clicker question, they knew they needed to add an immediate class discussion, asking students to explain why they chose their answers. Peyton explained,

> *Whenever we have a clicker response that's less than 85%, we'll spend time talking about why the right answer is right, why the wrong answer is wrong, and I'm always soliciting their voices for that. I've moved away from me explaining to getting them to explain and then affirming.*

Several faculty discussed the formative nature of the data they were collecting. In this example, Peyton (biology) again described doing formative assessment using clickers, alongside having students complete daily group assessments that they could then read after class to inform subsequent teaching practice. Peyton said,

> *I do formative assessment in my classes through clickers, but I also have daily what I call submission sheets, so the groups work together to answer a couple of concept type questions, and they turn those into me, and I read those each day.*

Several faculty talked about having students complete homework and pre-class quizzes on online platforms, which they claimed afforded them a quick, formative assessment of student comprehension, allowing them more immediate adjustment to their instructional practices. For example, Sidney, a chemistry instructor, noted that students took a pre-class quiz after first viewing a video in an online course environment. Before the class session, Sidney would meet with colleagues who were also teaching the class to discuss understanding as reflected by the quizzes across the complete array of students in the course. Sidney noted they had built flexibility into their courses to adjust their instruction to accommodate any changes that such data indicated the need for. Sidney stated this process was an improvement to trying to ascertain student understanding from, perhaps, fewer students that they could check in with in class.

> *Students are supposed to take a pre-class quiz, but the catch is that in order to be able to access it, they have to have first viewed the video. So ideally, it sort of forces them to watch the video and then take the quiz. The nice thing was that I and the colleague I taught with, we would have a discussion before class every time of, 'Hey, what questions on the quiz were they really getting? Which questions didn't they get?' . . . we were flexible enough that we could go into class that day and say, 'Hey, you know we realized we should spend a little more time on this.' That was a huge change that we hadn't [done previously]—we might have gotten a feel for it kind of walking around talking to students, but there we had very nice concrete data to inform what we would do and enough flexibility built in that we could say, 'Hey, today we're going to spend some more time going through Topic A quickly because most of you seem to be fine with that and spend more time on Topic B.*

Two faculty described adaptive learning technologies as affording them more immediately actionable data around their students' learning. Alex (chemistry) described adaptive technology as "a real eye-opener" related to their ability to respond and change their curriculum within days.

> *Adaptive learning has certainly been a refinement that I made because I went from an adaptive learning model where changes were being made to the curriculum based on student understanding, perhaps term by term, and now I've shortened that gap where feedback is immediate, evaluation is immediate, and then changes could be made for the very next assignment, which would be the next meeting. So I think that has been a real eye-opener in refining the response time, in that a change to the curriculum is not occurring the next term it's occurring within the term, and, as a matter of fact, up to within two days.*

Jodi (biology) found the adaptive learning technologies helpful in understanding trends over time and particularly useful in understanding how underrepresented and first-generation students were doing and where they might need more support.

> I think the predictive analytics things are useful if it's things like underrepresented minorities, first-generation college students, information like that, like more of the demographics of who my students are to figure out if there are pockets of the population that aren't doing really well in the class.

3.3. Impediments to Instructional Data-Use Practices

Faculty perceived several impediments to their instructional data-use practices. Constraints included (a) a perceived lack of time needed to implement instructional data-use practices, (b) standardization of course content, and (c) perceived lack of confidence and competence in instructional data-use practices.

3.3.1. Perceived Lack of Time to Engage in Instructional Data-Use Practices

Six faculty described how some instructional data-use practices took a great deal of time to implement and were therefore difficult to utilize effectively. Casey, a chemistry instructor, said that time constraints hindered their ability to try new or innovative practices, and they viewed this as a problem with implementing new practices.

> *Time constraints definitely hinder it [data-use practices], and they hinder actually doing anything innovative. That's actually a huge problem.*

Madison, a mathematics instructor, saw instructional data-use practices as necessary, but those practices were often pushed to the side by other instructional activities. They said, "Important things [like collecting instructional data] go to the back burner when the rubber hits the road, even when you know they're important." One faculty talked about the difficulty of fitting the instructional data-use practices into their curriculum. They wanted to do more and thought it was necessary but felt constrained by established practices.

> *That's definitely something I've wanted to do more of, just the issue of where do you fit that into the curriculum, but I think that's important, and I wish I was doing more.*

Two faculty stated their instructional data-use practices were constrained by a lack of time, as they often taught large classes. Casey, chemistry, elaborated that large class size can equate with a lack of time to implement instructional data-use practices, at least ones they felt significant. They described having students complete short writing assignments if students were struggling. Although they acknowledged that students gained from this experience, they also acknowledged that this type of practice was difficult to do with hundreds of students to measure student learning. Casey said,

> *A lot of times, I'll do a short writing assignment, especially if I think they're struggling with a concept, I'll have them write about it. But there's hundreds of them, so it's difficult to get a lot out of that, although the students get a lot out of it.*

Madison, mathematics, felt constrained by class sizes and the number of classes that instructors taught per quarter, and other responsibilities that influence data-use practices such as making exams predominantly multiple-choice.

> *Because of the class sizes and some people are teaching, some of the instructors are teaching four courses per quarter. I have another portion of my job is managing the math learning center, so I usually only teach three, but when they have that size classes, a large portion of the exam needs to be multiple choice.*

3.3.2. Constraints Due to the Standardization of Course Content

Several faculty (5) perceived constraints in using different kinds of instructional data-use practices due to the "standardization" of course content taught by various faculty and usually indicated requirements for standardized exams and grading policies. In some cases, these constraints were tied to whether the course was a sizable lower-division course taught by several faculty simultaneously at the same institution. In other cases, faculty described being constrained in their practices if the course was also taught at a community college or as a dual credit option in local high schools. While all faculty indicated they had autonomy concerning *how* they taught, several faculty indicated they were constrained by requirements related to student assessments of learning. Kelly, mathematics, said, "Most of the assessment I do is out of my control. Sixty-five to seventy-five percent of the grade for the courses I teach have to come from two midterms and a final." Notably, such realities were most often detailed by mathematics faculty. Still, Kelly talked about moving towards more group exams, a novel practice, and described the reluctance (i.e., constraint) within their department to adopt this practice.

> *I'm slowly trying to have conversations with the powers that be in the department to be adjustable [with doing exams] so maybe we'll do group exams, or maybe we'll try some other things other than just those very traditional midterm and final exam structures.*

3.3.3. Perceived Lack of Confidence and Competence in Instructional Data-Use Practices

Several faculty (4) stated a lack of confidence and competence in collecting and using instructional data to inform teaching practices. Bailey, an engineering instructor, described their instructional data-use practices as "terrible" in relation to more effective practices that they knew existed but did not know enough to implement.

> *Yeah, they're [instructional data-use practices] terrible. I know enough to reject a lot of common practices, but not enough to replace them with better alternatives. So I am really struggling with that right now. It's not formulated at all.*

Leslie (mathematics) also perceived instructional data-use practices as the weakest part of their teaching. They understood the importance of assessing student learning and formative practices specifically but struggled to respond to data in their teaching practice directly.

> *I would say that's probably the weakest part of my teaching practice. I'm not really formal about incorporating results of assessment into teaching, which sounds pretty bad. Yeah. Formative assessment, I read the literature, I drink the kool-aid, but that is the thing I drop the most in terms of my teaching practice. What I do is so informal. I don't know if I can even describe it.*

Another faculty was uncomfortable with their colleagues finding out about their instructional data-use practices. They perceived pushback that could result, partially based on their already being seen as an outsider in their field per their gender. They did not want to advertise what they did differently because of the possible repercussions they would experience.

> *You know, gender-wise, honestly, I've come into this profession, and I've been an outsider. I'm not going to take something I do that's different than what other faculty members do and advertise it. I may be very successful at it, but if I advertise it, there will be repercussions.*

3.4. Engaging Students in Reflecting on Their Own Learning Data

The overall sample was mixed in their practice of engaging students in reflecting on their own learning data. A slight majority of faculty (n = 10, 53%) indicated that they did not implement any instructional practices for students to engage with or reflect on data around their learning. Of these instructors, five instructors stated they did use formative data to inform their teaching practices. However, they did not explicitly use these data to engage students in reflecting on their learning. Lynn, engineering, described providing students with exam scores, a bell curve showing averages, and the range of grades, but no other data. When asked if students had an opportunity to reflect on their learning, they said,

> *Oh, no. Not aside for their own grades. They see averages and things like that. I guess that's really professor-dependent, but for me, whenever I go over the exam, I always put out the bell curve and say this is the average, this is the standard deviation, this is the range of grades.*

Two faculty mentioned the institution's end-of-term student evaluation of teaching survey as a means of students reflecting on their learning. One faculty stated they added a question to the survey related to whether students understood a particular concept covered in the course. Tracy, a chemistry teacher, said they would advocate for other faculty to do this kind of practice.

> *That's the one where we add the question on their electronic evaluation of teaching, so in the electronic evaluation of teaching for the students, there's a series of standard questions, I think there's ten, how was the course basically, what was the instructor's contribution to the course and there's a few others, and then I add, and I advocate for all other faculty to do this as well, you add at the end of this course [a specific question related to the content].*

Still, around half of the faculty (n = 9, 47%) indicated they implement instructional practices that engaged students in reflecting on their learning data. These practices were generally described as activities in which students were asked to reflect on their overall performance in class and how their use of study techniques may (or not) be helping them. Jordan, a chemistry instructor, stated, "I really try to actively engage them in utilizing critical self-review and then coming together with others once that review has taken place to gather the information necessary to move forward."

Alex (chemistry) described posing to students open-ended questions on worksheets, asking them to describe whether they understood the material and how comfortable they were with their learning. Alex perceived this type of student reflection as allowing students more autonomy with their learning.

> *[in the student's voice] "I understood this material, I feel comfortable with this material," and then they [students] produce a little bit of evidence and they will say things like "I am completely lost on buffer systems, I have no idea what is happening in a buffer system. I don't even know what a buffer system is." I think that's part of the empowerment [of students]. I think that's part of their confidence in that this seems to be very meta. So, students are plugged into their empowerment and their own understanding. They're not looking at it as how I did on an exam. They're looking at it as, I think I get this, I'm supposed to be learning these key concepts.*

Drew, a mathematics instructor, had students keep a journal of their progress in understanding course concepts and any related difficulties. Students received credit for their reflections.

> *In some courses, I've gone as far as actually having students keep a journal of what they struggled with that they actually turn in with the homework. So there's actually some "credit" awarded for going through that exercise. But I think the bigger value of that is getting the students themselves to reflect on their own learning.*

Jodi, a biology instructor, had students do "real-time" writing in class in response to a question. They would write on a notecard and hand it in. While this served as formative

feedback for Jodi around her practice, she also saw it as an opportunity for students to reflect on their learning data.

> *When I'm teaching in the classroom, I also have them do some real-time writing. I think writing is a really good way to start to help them see what they don't understand. So I have them do an individual note card where they write down an answer to a prompt, and then I have someone else, not me, read them, because there are seven hundred of them, and give me some summaries, and then I go back over that with them in the class as sort of a way to see if their thinking is right or what is a good response to these things versus what's not a good response to these things. So those are kind of the way I think that they get to reflect on what they're learning.*

Lee, engineering, used a formative instructional data-use practice, "the muddiest point type thing," to have students reflect on their level of understanding.

> *I often will do the muddiest point type thing, which has them reflect not so much on performance but on their level of understanding.*

Two faculty described using peer or small group activities to afford students opportunities to reflect on their learning. Casey, chemistry, has students complete short writing assignments, especially if they struggle with a concept. They describe collecting the writing but also giving students time to share in groups with assigned friends.

> *Sometimes they give them to me. They are in groups, they have assigned friends in my class, so they do share among their group members also.*

Kelly, a mathematics instructor, had students engage in self-reflective activities during a "recitation class," where students from a large-enrollment main class meet in smaller groups to work. Students discussed their homework assignments and compared answers to those given by the instructor.

> *It [student reflection on their own learning data] gets facilitated in smaller groups, in like a recitation situation. So normally my lecture would have a hundred people and then one day a week there's four different classes of twenty-five. When [students] get their written homework back with some sort of marks on it, they're encouraged to look over that and discuss the solutions that have been provided by me. They're asked to compare and contrast between what their answer looks like, what the solution organization looks like. It's the logical thought process of putting things together that I want them to focus on. So it's sort of done in small groups, face-to-face discussions.*

4. Discussion

4.1. Instructional Data-Use Practices and Motivations

In this paper, we report on a study of STEM faculty members' instructional data-use practices, including the types of instructional data that faculty collected. In general, faculty claimed to use multiple instructional data-use practices to inform their teaching practices and their students' learning. We found that all faculty described mostly gathering data via summative assessments, such as mid-term and final exams and weekly quizzes. While a few faculty also discussed written assignments they generally gathered, most data coming from summative assessments were qualitative in nature. Faculty indicated they used these assessments most often in classes they described as large-enrollment and generally administered them two or three times during the term. Most faculty perceived summative assessments as practical in providing measurements of student learning and determining grades. Several faculty indicated these were the only means for individual students to demonstrate what they had learned as opposed to other types of more formative assessments or group work.

However, a few faculty acknowledged that summative evaluations did not always reflect student progress. For these faculty, their perceptions of the value (i.e., importance) and function (i.e., purpose) of summative assessments had evolved to privilege more formative assessments. Several of these faculty indicated their concern that diverse students

did not have ample opportunities to demonstrate their learning via more traditional and common (i.e., summative and qualitative in type) assessments, in essence questioning the quality of the data to inform their teaching. These practices minimized the impact of more common and traditional assessments on students' overall grades in the course. A small number of faculty were considering experimenting with students working in small groups and giving presentations, instead of formal exams, or having students take exams together; a practice that faculty perceived would need further discussion with department colleagues or leadership before implementing.

Roughly half of the faculty we interviewed also gathered formative data that they perceived gave them more immediate ways to assess student learning. Much of this data was qualitative in nature, collected via course artifacts or verbal exchanges. Such artifacts as "submission sheets" and "muddiest points" asked students to evaluate or respond to a prompt or question about the course content. The purpose of these novel strategies was to intentionally provide a more collaborative and inclusive process for students to demonstrate their learning that still offered them insight into students' learning and interests. Faculty also described these as less stressful ("low stakes") for students when compared to formal exams.

Some of these findings indicated an awareness on the part of faculty that not all students bring the same background and experience to STEM coursework, which would make more traditional and common assessments less than meaningful for them as educators. These faculty, thus, knew to implement other assessments that would allow a wider array of students to demonstrate the learning and progress faculty expected they were making. Faculty use of activities that provide students with "low stake" options seemed especially promising in promoting students' success across the diversity of learners in their courses. Through their implementation of these less stressful assessments, faculty also provided students means to ask for more review or coverage of particular topics. As they did this, faculty may have been engaging students in determining the pace and depth of content coverage, all the while sending a message to students about their role and agency in their learning. These faculty practices are promising per research that demonstrates a recognition of student achievement and faculty responsibility in creating more equitable learning environments [40,41].

Some of the formative data that faculty collected were of verbal form, described as some of the most informative data faculty collected about how students were doing in their courses. These included having an open discussion in class, talking to students during office hours, and talking with learning and teaching assistants about student progress. These findings are also promising, as faculty interactions with students are essential in building rapport and positive relationships with students [42] and can ultimately enhance student success [43]. Many of these interactions resulted in verbal data that were described as informal, such as asking students questions during office hours or talking with them one-on-one during class or as groups in work sessions. While we did not explore with faculty the proportion of students faculty connected with via these informal interactions, we assume that these informal interactions may not have involved all, or even most, students. There may, in fact, be a reason to be concerned that some students may find these interactions with faculty intimidating and be unwilling to share areas where they may be struggling due to their perceptions of the potential reactions of the faculty. Some students, additionally, may feel unable to initiate such interactions (as during office hour visits). This reality may position students not comfortable, agentic enough, or able to make time to talk with their instructors at a disadvantage [43,44], including those struggling as well as those succeeding, both groups that can provide faculty important insights into their teaching. A few faculty described using their learning and teaching assistants' assessments of student comfort and understanding of the material as indicators of student progress. This strategy provided indirect data gathering from students that may counteract our last concern, allowing faculty insight from students who do not feel comfortable talking to them directly. Faculty might consider fostering more of these interactions of their students with others

who students may see more as peers to collect meaningful and timely, learning-related data to inform their teaching.

Additionally, we need to consider the potential limitations of data that faculty reported collecting, including those which may seem to be more anecdotal. Andrews and Lemons [17] found that postsecondary biology faculty primarily relied on personal perceptions and experiences rather than empirical evidence to inform their teaching practice. They found that using data to convince faculty to change was ineffective. Indeed, this may be one reason that faculty may not be willing to change comfortable, already established practices, especially if departmental climates further stifle the implementation of novel practices. Professional developers and education leaders might need to help faculty recognize this limitation and find a "sweet spot" between the comfort, ease, and meaning they feel (for themselves and students) around verbal, informal formative data and data that is also valid and reliable. Faculty in our study indicated a concern for the meaningfulness of more common, traditional assessments such as multiple-choice exams that may not demonstrate student learning. Overall, our study points to how we must help them evaluate, modify, and create instructional data-use systems that sit at the intersection of being reliable and valid, as well as meaningful and usable. These systems must also be practical, timely, and engaging for a majority of diverse students.

4.2. Impediments to (Meaningful) Faculty Instructional Data-Use Practices

Many of the summative and formative data types we heard about were consistent with Bouwma-Gearhart's [4] and Hora et al.'s [5] research with postsecondary STEM faculty. These researchers, too, found a diverse repertoire of practices used to measure student learning to inform their teaching. They, too, found that most faculty relied predominantly on summative and largely quantitative forms of data to inform teachings. Some faculty also relied heavily on formative and qualitative forms. Also consistent with the findings of Bouwma-Gearhart, Hora, and colleagues were the constraints that faculty identified as limiting their instructional data-use practices. These impediments included a perceived lack of time needed to implement instructional data-use practices, standardization of course content that restricted the types of practices used, and departmental structures that determined some types of practices. Like Bouwma-Gearhart, Hora, and colleagues' research, ours suggested that many STEM faculty may generally not feel prepared or empowered to effectively utilize diverse forms of instructional data to inform their teaching practice. Survey data that helped to motivate this study (detailed in the methodology section of this paper) pointed to a general lack of confidence and competence in collecting and using instructional data by faculty. Our study confirms this, mainly around qualitative and formative types of data.

Our faculty participants noted several nuances around the impediments to their instruction data-use practices. Specifically, time constraints revolved around certain types of formative assessments (e.g., journaling, group exercises), especially in large classes. Although faculty acknowledged that these formative assessments were valuable and even necessary, they were not always implemented. In part, faculty felt pressed to cover content, which suggests a perception that certain types of instructional data-use practices (e.g., formative) were somehow outside regular teaching norms and therefore needed to be added or fit into the class.

Notable too were mathematics instructors' laments of the "standardization" of course content. This usually indicated departmental requirements for common exams and grading policies. In some cases, this indicated large introductory courses that were taught by multiple faculty. These departmental structures suggested that faculty were not empowered to gather, analyze, and use instructional data to meaningfully inform their specific teaching-related questions and practices or to help students reflect on their learning achievements, a reality hinted at elsewhere in the literature (e.g., [5,23]).

Those faculty stating a lack of confidence and competence in collecting and using instructional data admitted it was the weakest part of their teaching. Faculty understood

the importance of using instructional data-use practices to assess student learning, but they struggled with responding to data in their teaching practices. One faculty, additionally, was uncomfortable with their colleagues finding out about what they did to assess student learning. They perceived pushback from colleagues, partially based on their perception of being seen as an outsider in the field per their gender.

Attending to faculty comfort and norms with instructional data-use practices is one step in promoting faculty engagement in this research-confirmed practice to improve teaching. Interestingly, in comparison to Bouwma-Gearhart, Hora, and colleagues' study, faculty in our study were all involved in teaching improvement initiative activities and had largely been involved in multiple teaching improvement initiatives in their past. Arguably we might assume these STEM faculty are the most confident and competent (when compared to peers not engaging in such initiatives) in gathering, analyzing, and responding to data. Limited research points to STEM faculty members' participation in teaching professional development opportunities as predicted by their previous participation, as long as past opportunities were meaningful; in essence, those involved in improvement initiatives should be some of the most aware and practiced in implementing research-based teaching practices [45–47]. If this rationale is correct, and arguably we are in need of more research to confirm this, it points to multiple implications, namely that 1) many (most?) initiatives still do not focus on instructional data-use practices, and/or 2) such initiatives are not especially fruitful in expanding faculty practice around instructional data-use. Either reality presents implications for department leaders and professional development experts who aspire to support faculty development towards improvements to their teaching and, ultimately, student success.

4.3. Supports of Faculty Data-Use Practices

Faculty claimed multiple affordances for their instructional data-use practices that informed their decisions related to their teaching. Most faculty pointed to data they collected that provided insight around their teaching as data types and means that were norms for them as practitioners within their larger departments and organizations. Most faculty and departments privileged traditional types of student learning data such as exams and written assignments. Nevertheless, faculty also claimed they used other data to inform them of students' learning, not traditional assessments. Several faculty claimed narrative and verbal forms, as discussed earlier, provided them novel and timely data to assess student learning and allowed them opportunities to interact and respond to students. However, most faculty still relied primarily on traditional methods, like exams, to gather quantitative data to inform their teaching. Faculty did seek different and more nuanced information, largely qualitative and formative, and several faculty tried to help students feel more comfortable and relaxed in demonstrating what they had learned. Learning and teaching assistants were other affordances that a few faculty used to gather data on students' achievements. Those faculty described developing a learning assistant program made up of former students who provided feedback on what was working or not related to the courses and students' understanding of concepts and content.

We found instructional technology afforded most faculty multiple instructional data-use practices by providing them with opportunities to collect and use data in different ways, such as clickers, online homework, adaptive learning tools, and other uses. Faculty who incorporated instructional technology tools in collecting student learning data were more likely to collect formative types of data. Having relatively easy access to large amounts of formative data encouraged faculty to collect this type of data more often and make more immediate or next-class-meeting changes to what content faculty would teach and what teaching strategies they would use. Instructional technology eased the burden of collecting, especially in large classes. In some cases, this allowed instructors to share student learning data with their students more readily. Faculty also used instructional technologies to assess trends in different groups of students, suggesting that some faculty intentionally recognize and attend to achievement gaps. In short, faculty who used instructional technology to

collect data, largely formative, indicated they modified their instructional practices more often and quickly than those who collected data in other ways. Furthermore, they were more likely to engage students in reflecting on their learning. We think this finding is important because it adds to our understanding of how faculty perceive the instructional technology often, though not always, at their disposal, technologies that are often pointed to as allowing educators' data-based decision-making. Indeed, the faculty we spoke to claimed instructional technologies afforded them collecting different kinds of data and the ability to assess trends in student learning in a timely manner. Our research somewhat confirms the exploratory research of Hora and Holden [23] on the role of instructional technology in STEM faculty's practices and backs their assertion that understandings around faculty practice are needed to design more locally tuned interventions, and that faculty must see the technology as salient to their practice. Based on our more nuanced findings regarding faculty's use of instructional technology, we recommend those who have responsibility for adopting and implementing instruction technology consider that faculty use instructional technology for multiple reasons and in multiple ways. Thus, including faculty in the decision-making process can result in more faculty adopting and using it.

4.4. Engaging Students in Reflecting on Their Learning

Our findings suggest that faculty were mixed in their practice of engaging students in reflecting on their learning data. Those faculty who did indicate they implemented these practices described activities where students reflected on their overall performance in class, such as open-ended questions that were added to daily in-class or homework assignments. Some faculty asked students through journaling activities to talk about their use of study techniques that may or may not be helping them. Again, these findings are promising, based on other research confirming structured and unstructured activities such as engaging students in journaling and open-ended questions that asked students to write about what they were learning or having difficulty with. These are effective strategies for promoting students' reflection on and understanding about their learning [21,30].

Still, a majority of faculty indicated they were not intentionally engaging their students in reflecting on their learning. Faculty described doing this least so with students in their lower-division courses, primarily based on the perception that students lacked the ability to meaningfully reflect to the degree that upper-division students could. These faculty claims seem to suggest their assumptions that students have to achieve a certain level of cognitive development and/or understanding in a discipline before they can engage in reflecting on their learning. This may also suggest a faculty perception that students acquire reflection skills through means other than activities that are directed by themselves as their course faculty. Such assumptions may very well be unfounded [29]. Regardless, such thinking shifts the responsibility for student learning entirely to students' shoulders and suggests that faculty bear little responsibility for helping students be reflective learners. We assert that faculty need to provide opportunities for students to reflect on their learning in order for the student to gain an understanding of the particular aspects of their work that they need to attend to in order to be more successful. Professional developers and leaders can help by providing examples of practices that can be incorporated into classroom activities effectively and that engage students in meaningful reflection on their learning.

4.5. Further Recommendations

Throughout our above detailing of findings concerning STEM faculty instructional data-use practices, we have noted some recommendations for faculty leaders, professional development experts, and faculty themselves to design initiatives that support faculty practices that improve teaching and student learning. Largely, these are towards what we see as the main goal of our study, that is to build from what we know to be working, around important faculty realities and needs towards improving the frequency and efficacy of instructional data-use practices, including faculty engaging students in more meaningful

reflections on their learning. Here we detail recommendations more by main theme and stakeholder group.

- Faculty leaders and professional development experts must foster *ongoing and targeted professional development activities* that support faculty toward improving their instructional data-use practices based on best practice research. Professional development activities can elicit perceptions and experiences that will help faculty see which instructional data-use practices afford them the greatest potential for analyzing instructional data that improve their teaching practices and student learning.
- Faculty leaders and faculty must *commit to innovating and developing their use of instructional data-use practices* by recognizing that research-based instructional data-use practices can inform their teaching and improve student learning. Faculty are encouraged to explore the potential for collecting more formative data and finding efficient ways to gather and use it in timely and relevant ways to inform their teaching and students' learning.
- Faculty must *recognize the shared responsibility* for providing students the opportunity to reflect on and improve their learning. Fostering students' ability to reflect on their learning has implications for students and faculty through increased learning and achievement for students and data that inform adjustments to teaching that can enhance student learning.
- Faculty are encouraged to *take advantage of instructional technologies* available to them to enhance the gathering, analysis, and response to instructional data. Increasing faculty competence in collecting and responding to data that involves instructional technologies is critical. Faculty leaders and professional development experts must guard against mandating technology that is not perceived as relevant and usable.
- Faculty leaders and faculty are encouraged to *reevaluate curricular content development and processes* that may stifle faculty instructional data-use practices and explore changes to policies and norms that promote more research-based instructional data-use practices.

Understanding faculty perceptions about instructional data-use practices can further support professional development activities that help faculty understand their use and beliefs about effective instructional data-use practices. We know that faculty perceptions and practices are based on their previous experience, perceptions, attitudes, and practices [48,49]. Any targeted professional development strategies that better support faculty must account for these realities. Indeed, faculty are much more likely to feel competent in using instructional data when they have a say in their experiences with the instructional tools and the teaching practices that effectively incorporate instructional data in daily processes (Hora and Holden, 2013). Professional development activities must invest faculty in the data-driven decision-making processes that make sense.

4.6. Future Research

Faculty instructional data-use practices, and the perceptions and realities that root them, can inform future research and interventions towards postsecondary STEM education improvements, ultimately towards enhanced success for diverse student populations. Our study is one step in this direction, yet there is still much to discover. Future research could explore more nuanced faculty perceptions and practices across disciplines, including across STEM. Indeed, STEM is not a monolith [50], and we need to explore differences that may exist for faculty and their organizations that may rely on different ways of knowing, cultures, and structures [51]. For instance, are there instructional data-use practices that faculty find particularly effective in certain disciplines? How can departments and institutions support effective instructional data-use practices and still maintain requirements mandated across their specific stakeholders (e.g., faculty and students, accreditation bodies, industry)?

More research is also needed that further explores the impact of instructional technologies on actual faculty practice. For instance, how do faculty incorporate these tools, and what intervention strategies are most helpful in supporting their actual use? What

technologies generate the most meaningful and efficient data for faculty to inform their teaching? How can department leaders and professional development experts support faculty in engaging students in reflecting on their learning? What professional development activities increase faculty confidence and competence and actual use of instructional data to inform practice? What data provide the most reliable and valid read for faculty across numerous problems of practice? Future research could also explore the most effective and efficient ways that faculty can engage students in reflecting on their learning. What else inhibits faculty from engaging students in reflecting on their learning, given the benefits for students? What data are most effective in providing students accurate and discipline-aligned insight for students? What practices best inspire students to accept their agency in assessing and ensuring their learning across STEM disciplines?

5. Conclusions

Faculty and student interactions in learning environments are complex. Given a relatively typical target of postsecondary education improvement interventions, we are especially in need of understanding how and why STEM faculty gather, analyze, and respond to instructional data. This study adds to the limited research that examines STEM faculty's instructional data-use practices. As research has confirmed, innovation and changes to instructional practices can be slow and challenging. However, we contend that this study indicates some research-confirmed instruction data-use practices of STEM faculty that inform their teaching. STEM faculty now, more than ever, may be attempting more effective and inclusive strategies to assess their students' learning, reflecting a diverse student population who has not traditionally experienced sustained success in STEM files. Faculty are recognizing and incorporating more formative types of data and rethinking how they are using summative data to determine student learning and grades. Faculty may be incorporating more instruction technology that provides them with more strategic ways to collect student learning data and to respond in real-time teaching. We suggest that departmental leaders, administrators, and professional development experts are critical in the continued support of faculty in their development of effective data-use practices that make sense per their and their students' realities. We see a need for more research that explores these realities to strengthen and expand support efforts.

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Appendix A

Interview Protocol
Faculty Interview Questions

1. I'd like to know more about your position at (Name of University).

a. Specifically: What is your official title?
b. What classes did you teach this academic year, 2016–2017?
c. Have your teaching responsibilities changed since last interviewed for this project?
d. How much autonomy do you have over what and how you teach?

2. Do you interact regularly with any others concerning issues of teaching and learning?

a. (If yes), please provide detail regarding those interactions: including
    i. who? 1. Are these people in your discipline/department/program?
    ii. how often?
    iii. regarding what specifically?
b. What encourages or discourages these interactions?
c. Has (Name of Initiative) influenced these interactions in any way?

3. I'd like to hear about your engagement with the (Name of Initiative) project. Specifically:

a. What has been your affiliation with the (Name of Initiative) project? What activities have you attended?
b. Have you noted any impact of (Name of Initiative) on you?
c. Have you noted any impact of (Name of Initiative) on others?

4. Please describe any evolution in your teaching practices over the last couple of years that you can attribute to improvement initiatives or professional development activities. (If not mentioned, probe for specifics via questions a and b).

a. Have any university or departmental initiatives or teaching professional development opportunities impacted this evolution?
b. Has (Name of Initiative) influenced your evolution in any way?

5. I'd like to hear about your assessment practices while teaching.

a. To what extent do you collect data/information about student learning?
b. Are you teaching practices informed by data/information about student learning?
c. Are there means in the classes/courses that you teach for students to reflect on their own learning data? (If yes), Can you detail these processes?

6. Describe a successful student in the courses or programs in which you teach.

a. Overall, what do you consider as the most effective teaching strategies towards developing these things?
b. To what extent do you employ these teaching strategies?

7. A goal of the (Name of Initiative) project is widespread improvement to teaching practices and learning outcomes in undergraduate STEM education across (Name of University). Our general strategy is promoting educators' learning about evidence-based instructional practices via interactions with other educators.

a. What do you think about this goal and strategy? Do you have any evidence that widespread improvement to teaching practices and learning outcomes in undergraduate STEM education have happened in the last couple of years at (Name of University)?
b. Can you attribute any changes to the (Name of Initiative) project?
c. Have you noted any affordances and barriers towards widespread improvement to teaching practices and learning outcomes in undergraduate STEM education, that can inform efforts like (Name of Initiative)?

8. A specific goal of the (Name of Initiative) project was to promote active learning and cooperative learning, especially in large, introductory, gateway courses. We define active learning and cooperative learning as X (definitions provided to interview on a handout).

a. What do you think about this goal and strategy?

b. Do you have any evidence that promote active learning and cooperative learning has increased in large, introductory, gateway courses in the last couple of years at (name of university)?
c. (If so) Can you attribute any changes to the (Name of Initiative) project?
d. Have you noted any affordances and barriers towards active learning and cooperative learning has increased in large, introductory, gateway courses, that can inform efforts like (Name of Initiative)?

Appendix B

Code Names	Code Descriptions
Narrative Data Practices	Informal methods of collecting student learning data. Different formats: (a) examination of curricular artifacts, (b) notes to self about curricular artifacts, (c) qualitative data such as exit slips or muddy point exercises.
Numeric Data Practices	Numeric data practices include formative data, summative data, and student evaluations.
a. Formative Data Assessment Strategies	This code indicates strategies that were formative in nature and usually done throughout the course. Data are collected on the spot using technology such as clickers and online pre-quiz activities. Data are analyzed in real time and changes or adjustments are made to teaching practices and decisions quickly.
b. Summative Data Assessment Strategies	Commonly used forms of assessment such as weekly homework assignments and quizzes, midterms, final exams, and essays. Analyzed at the end of a section or term to guide decisions about teaching and course design for the next term.
c. Student Evaluation of Teaching Assessment	Data collected from students at the end of the term regarding feedback related to instructor's teaching practices. Generally done through an institution-wide process.
Verbal Data Practices	Verbal data collected by the instructor either through talking with students or talking with teaching assistants or other instructors.
Sample of Codes and Definitions	

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Learner-Centred Learning Tasks in Higher Education: A Study on Perception among Students

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Abstract: Universities face the challenge of constantly improving the quality of higher education and changing the learning behaviour of students, from passive reactive learning to active self-regulated learning. Learner-centred, constructively designed learning tasks offer a great opportunity here. This paper investigates to what extent the learning process is challenged by these learning tasks, and how these tasks are perceived by the students, using a before and after survey of students studying at bachelor level in business courses at a German university. The paper starts with a short description of constructivism in the context of task design and the main characteristics of learner-centred, constructivist-orientated learning tasks: openness to problems, situation orientation, openness to solution paths, and degree of difficulty. Then the research method used is outlined before the findings are presented. The before and after survey shows that despite an increased complexity and workload, the motivation to deal with topics on the subject remained stable.

Keywords: self-directed learning; learning tasks; student surveys; university didactics

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1. Introduction

The increasing competition among universities confronts them with the challenge of maintaining the quality of studies and teaching at a competitive level, both nationally and internationally, and of constantly improving teaching [1].

In light of the above, approaches to activate self-directed learning have moved into the focus of current discussion [2,3]. For example, Mandl, Gruber, and Renkl [4] have found that in traditional forms of university teaching, students often acquire "inert" knowledge (knowledge that the learner is unable to apply). The learning behaviour of students should therefore be changed from passive memorisation to active transfer-orientated learning [5,6]. Lecturers, in particular, are thus increasingly faced with the challenge of ensuring the competence of students through learner-centred methods [7]. This form of self-directed learning is particularly problematic in large university courses because of the large number of participants, since learner-centred methods such as discussions, group work, and so forth, are challenging to use within large groups [8–10].

At this point, learning tasks in university teaching offer a great opportunity to promote analytical, learner-centred, and self-directed learning [11], since they encourage the application of knowledge and encourage the use of the content learned to solve real problems [12,13]. However, a shift from a teacher-led learning culture to a self-directed form of learning can also be dangerous. Vermunt and Verloop [14] (p. 270) speak of the danger of "friction" if the teaching strategy and the learning strategy do not fit together; the students are over- or underchallenged and they consequently do not gain a learning effect or, in the worst case, the learning effect is negative.

Currently, the use of learner-centred learning tasks, especially in business management courses, has not been sufficiently researched. With regard to learning tasks in higher education, the studies of van Merriënboer and Kirschner [11], and Hoogveld, Paas, and Jochems [15], which dealt with the construction of learning tasks for university teaching,

are significant. Their works deal with a model for the construction of learning tasks within the framework of university didactics. Based on this model, various continuing education programmes for lecturers have been developed and empirically evaluated [11,15]. Furthermore, the abovementioned studies take the perspective of the lecturers and the implementation of learning tasks by lecturers, in other words the teaching style, as their main focus. The question of the extent to which students are able to deal with self-directed learning tasks, and whether these are compatible with their own learning strategies, has hardly been researched. This paper addresses this research gap, examining students' perceptions of the use of complex, learner-centred learning tasks in bachelor level business courses at a university in Germany. The change in teaching strategy is achieved by adapting the tasks used in exercises and tutorials in the past, to constructivist-orientated, self-directed learning tasks. Specifically, it was investigated to what extent the learner's learning process is challenged by these learning tasks, and how these tasks are perceived by the students. Therefore, the research question is:

How do students perceive the increase of cognitive level, complexity, and openness of learner-centred learning tasks?

This paper starts with a short description of constructivism in the context of task design. Then the research method used is outlined, before the findings are presented, followed by a discussion and a view to future outlook.

2. Constructivism as a Basis for the Construction of Learner-Centred Learning Tasks

On a theoretical level, the learning task concept pursued here is linked to constructivist learning theories. Billet [16] describes how learning is enabled by two important elements. On the one hand, the presentation of knowledge as a specific situation from the field and, on the other hand, the thinking activities that construct, modify, and apply this knowledge in order to deal competently with situations in this field. Specifically, this study is based on the eight principles of the constructivist-orientated problem-based learning environment of Savery and Duffy [9], which cover both knowledge presentation and thinking activity. These principles are [9] (pp. 137–140):

1. link all learning activities to a problem or to a larger task;
2. support learners in developing ownership of the overall problem or task;
3. design an authentic task;
4. design the task and the learning environment to reflect the complexity of the environment in which the students will work after their studies;
5. give the learner the ownership to develop their own solution processes;
6. design the learning environment in such a way that it supports and challenges the learner's thinking process;
7. encourage the testing of ideas against alternative views and in different contexts;
8. provide opportunities for reflection on the content learned and the learning process itself.

Learning tasks are understood to be tasks that serve the purpose of learning or practicing knowledge. They are a matter of material control of the learning process [17]. Constructivist-orientated learning tasks should be designed according to these eight principles.

Based on these principles, characteristics of constructivist-orientated learning tasks were derived. The first two principles of Savery and Duffy [9] emphasize the problem: "openness of learning tasks", which embeds the learning tasks in a larger context. The learning tasks should be formulated in such a way that learners are confronted with a question or problem. Learning tasks must have a stimulating quality that results from a challenging and motivating problem orientation [3]. The development of learning tasks becomes more significant and more realistic if the work instruction within the learning task is not too clear, and the learners themselves must identify the problems to be worked on [9] (p. 139). Problems should not be clearly specified, but at best should be discovered by the learners themselves in an open process.

Savery and Duffy's [9] third and fourth principles aim at the characteristic of: "situational orientation" of learning tasks. It is of particular importance in knowledge transfer, to show the learners in which practical context the learned knowledge is applicable. This situation orientation is understood as a reference to everyday life and the world around us, as well as in the sense of authentic application contexts. Learning tasks that are integrated into a typical professional situation by means of a business reference show students the sense of learning [13,18]. In the context of a university degree program, the living world can of course also include the area of scientific work. The lack of embedding learning in authentic contexts can lead to a lack of transferability of the content learned [9]. Therefore, it is necessary that learning tasks with real, or at least constructed application relevance, promote the application of the learned skills in real life situations [19–21].

The fifth principle mentioned above by the authors refers to the "solution process" when dealing with the learning task. Constructivist learning tasks do not provide only one correct solution. The solution process can be designed openly, where learners are given the opportunity to pursue their own action strategies and goals by using openness in their solution path. Learning outcomes and solution paths develop heterogeneously and are regarded as fundamentally unpredictable [9,22]. If the solution paths are open, the learners need to decide for themselves which strategies, concepts, and procedures they use to solve the problem. The learners will need already pronounced metacognitive skills, since they will have to control their own learning processes in order to successfully complete the tasks; it is desirable that there should be different ways of solving the task. Different approaches are also desirable to encourage learners to develop their ability to deal with divergent forms of situated presentation [9]. In this way, unexpected task completion processes can be understood as a learning opportunity. In this sense, the openness of solution paths also fulfils the requirements of principles seven and eight, which refer to the evaluation of ideas and the reflection on the learned content.

In order to design the learning environment as described in the sixth principle in such a way that it supports and challenges the thinking process of the learners, attention must be paid to the degree of difficulty of the learning tasks. The cognitive level of the learning tasks must be carefully considered. This defines different gradations: whether the content is to be remembered, whether it is to be understood, whether it is to be applied in a similar way or to a new problem at hand, or whether learners are to acquire additional knowledge by themselves [23,24]. Ideally, learning tasks promote at least the level of application of the acquired knowledge in real situations in order to solve problems at a higher level [11,12]. The degree of difficulty of a task can also be regulated by the linguistic complexity [25,26]. This complexity is increased in a task, for example, if the partial aspects relevant for mathematical modelling are presented in a sequence according to logic of the situation, that does not need to be logical for the solution path, and the mathematical variables are named in the text. This is necessary because even in professional life not all information is presented in the way it is needed to solve a problem. Furthermore, complex sentence structures or formulations, which are caused by the authenticity of a situation, can also lead to an increase of the linguistic complexity. This complexity encourages students to independently work out the relevant information for the task at hand. Consequently, this characteristic also serves to fulfil the requirements of principles three and four, which refer to the authenticity and complexity of learning tasks.

In summary, the characteristics of learner-centred, constructivist-orientated learning tasks can be divided into the variables of openness to problems, situation orientation, openness to solution paths, and degree of difficulty. The property "degree of difficulty" in turn has the subcategories cognitive level and linguistic complexity.

3. Method

3.1. Research Design and Data Collection

In order to answer the research question, a research intervention with both before and after surveys was realised. The intervention covered the change process from traditional

small-step tasks which were part of four bachelor courses in business administration at a prestigious German university to constructivist-orientated self-directed learning tasks. To measure the effects, a standardised quantitative online survey of the students involved was conducted, to reach as many people as possible [27].

In the surveys mainly single and multiple-choice questions were used. The main items were assessed using a 4-point scale, in which the students rated comments on a scale from "totally agree" to "disagree". A 4-point scale was chosen to get a response tendency. There is no "neutral" option in the scale form. This procedure is suitable for capturing perceptions. Respondents were also asked to weight statements using percentages. The questions were derived from the above-mentioned theoretical principles and cover the derived variables of openness to problems, situation orientation, openness to solution paths, and degree of difficulty. In order to measure the effect of learning tasks, the motivational disposition plays an important role [28,29]. This can be revealed as a preference for a particular field of knowledge or action [30]. An individual develops extensive knowledge and skills through the motivation to deal with a topic. [18,28]. Additionally, the time spent for task processing per week was asked to investigate the objective workload of the students before and after the intervention, because the workload and complexity of the tasks define the learning context [31]. Therefore, the interest of the students in the respective subject matter was also surveyed. Questions were developed for the survey by the research team according to the theoretical framework. When formulating the questions, students were considered to have no previous pedagogical knowledge. Consequently, no pedagogical terminology was used, and the contents were paraphrased. The questions were formulated in such a way that the participants could understand them by reading them once and their motivation to complete the questionnaire was maintained. The questionnaire itself was divided into three parts: demographic data, perception of the learning tasks based on the constructivist dimensions, and additional questions about motivation and time expenditure.

Table 1 shows an overview of the relevant variables and the asked questions for the research question.

The validity of the questions was checked by a pre-test with five students of economics. Furthermore, an expert in quantitative research reviewed the questionnaire.

Table 1. Overview of the variables, questions, and scales.

Variables	Questions	Scales
Problem openness	With the work instructions, I was able to understand what was expected of me without further explanation.	totally agree agree rather disagree disagree
Situation orientation	I was able to apply the lecture contents in the task.	totally agree agree rather disagree disagree
Solution openness	I was able to work on the task according to my own solution path (e.g., calculation path, processing steps, argumentation structure).	totally agree agree rather disagree disagree
Cognitive demands	To answer the learning task, one had to …	… % only reproduce what you have learned by heart … % understand the … … % contents so that the tasks could be solved … % apply the contents to an existing problem … % acquire additional knowledge

Table 1. *Cont.*

Variables	Questions	Scales
Complexity	I was able to extract the information necessary for the processing from the task.	totally agree agree rather disagree disagree
Degree of difficulty	I find the level of difficulty of the task to be appropriate.	totally agree agree rather disagree disagree
Motivation	The task has motivated me to learn more about the subject area.	totally agree agree rather disagree disagree
Time spent	Processing the task took the following time per week: (without attendance time).	less than 1 h 1–2 h 3–4 h more than 4 h

The surveys were conducted before the COVID-19 pandemic began in the winter semester of 2017, the first student survey was conducted to analyse the perception of the learning tasks used so far in the lectures. This first survey aimed at students of those courses in which the tasks had not yet been changed.

In the summer semester of 2018, more than 300 assigned tasks were investigated for the characteristics of constructivist-orientated learning tasks, using a structured document analysis. The analysis grid was developed based on the above-mentioned characteristics of the learning tasks. The research team improved the learning tasks according to constructivist criteria in cooperation with the lecturers responsible for the courses.

In the winter semester of 2018, the lecturers used these improved learning exercises in their regular courses. In order to investigate the effects of the redesigned learning tasks on the students, the same surveys on the learning tasks used were conducted with another cohort after the intervention, therefore we had two different samples. The second survey was conducted to investigate whether there are any changes in the students' perceptions. Both surveys took place on one of the last course dates, so students had already completed most of the learning tasks. A member of the research team went into the seminar room at the beginning of the seminar and invited the students to participate in the survey. The internet address of the online survey was then shown on a presentation slide. Afterwards, an invitation to participate in the survey was sent out to the students by e-mail to also reach the students who were not present at the course on the day. This method ensured a high level of participation in the survey.

The date was evaluated on the basis of mean value calculations with a two-sample t-test for significance. The open-source calculation program R was used for the calculation.

The research team was not involved as lecturers in any of the courses. The survey was anonymous and was analysed by the research team. The result was presented to the lecturers of the courses involved. This separation between the research team and the lecturers minimised power differentials and coercion. The combination of qualitative document analysis and quantitative surveys allowed the investigation of different perspectives and dimensions of the intervention [32].

3.2. The Intervention

These four courses were exercises to deepen the content of the lectures. The courses took place weekly during the semesters. The courses each had more than 100 students and could be described as large-scale courses. There were two lecturers per course, with eight lecturers in total involved in the intervention. The lecturers were junior academics

with two to three years of teaching experience. The lecturers had little previous training in higher education didactics and so that the improvement of the learning tasks was closely supported by the research team. The research team showed the lecturers potential for the improvement of the old learning tasks and showed possibilities of how to improve the learning tasks according to constructivist dimensions. The lecturers then improved the learning tasks by themselves.

Both the discussions with the lecturers and the analysis of the learning tasks demonstrated that the tasks were not formulated in a constructivist manner prior to the intervention. In the revision of the learning tasks, reference was made to the constructivist-orientated characteristics presented above: openness to problems, situation orientation, openness to solution paths, and degree of difficulty, in order to proceed according to the eight principles of the constructivist-orientated learning environment according to Savery and Duffy [9]. In particular, the tasks with the cognitive level of memory were adapted to achieve the higher learning objective of "understanding and applying". Thus, in many learning tasks, the reproduction of definitions was abandoned after the adaptation. Instead, the students were asked to explain technical terms and concepts based on self-selected examples.

According to the situation orientation, individual units of knowledge were linked together in the revised learning tasks and partly enriched by linguistic complexity. The tasks were contextualized in typical business situations.

For example, a mathematical cost accounting task was revised by the following situated task.

Excerpt from the task: "You already suspect that your manager will not be satisfied with the resulting increase in costs. In order to prepare yourself well for the discussion with him/her, you should therefore give it some more thought. Which measures and concepts could be used to reduce production costs?".

Learning tasks where the solution paths were given in small steps through several subtasks were made more open by allowing students to freely choose the solution strategy.

The learning tasks became more extensive through the addition of practical relevance and higher degree of difficulty. Through this enrichment, the students are requested to filter the relevant information needed to solve the problem in the task by themselves.

In addition to increasing the complexity of linguistic logic and raising the cognitive level, the problem openness of the tasks was increased. The problem to be solved had to be identified by a situation analysis and is not clearly identified by the lecturers.

4. Results

In the following section the findings are presented according to the research question and the characteristics of the learning tasks already described. The results before and after the intervention are presented and compared according to the characteristics of the learning tasks.

Out of a total of 2495 students, 495 took part in the first survey. The response rate was therefore 19.92%. From the participants, 51.9% were female, 47.7% male, and 0.4% diverse, with an average age of 22.1 years. This second survey involved 481 out of 2350 students with an average age of 21.7 years. Of these, 58.2% were female, 41.0% male, and 0.8% diverse. The response rate was 20.47%.

The characteristic problem "openness" indicates that learners should identify the problem presented in the learning task through their own analytical performance in order to develop action steps by themselves. During the intervention, the learning tasks were revised in such a way that problems and work instructions were no longer identified separately but were integrated in a complex situation. Work instructions could only be derived after an intensive investigation of the situation presented. Consequently, the research question asked was whether the students can understand the content of the work instructions without further explanation and understand what is required. After the intervention (survey 2), the students answered significantly ($p < 0.05$ **) higher 2.21 than before the adjustment of the tasks (survey 1) 2.08 (scale of four: 1 totally agree/4 disagree; see Figure 1). The clarity of the work instructions was reduced. The before and after survey

showed that in comparison to the initial situation it was now more difficult for the students to independently recognise the specific problem to be solved.

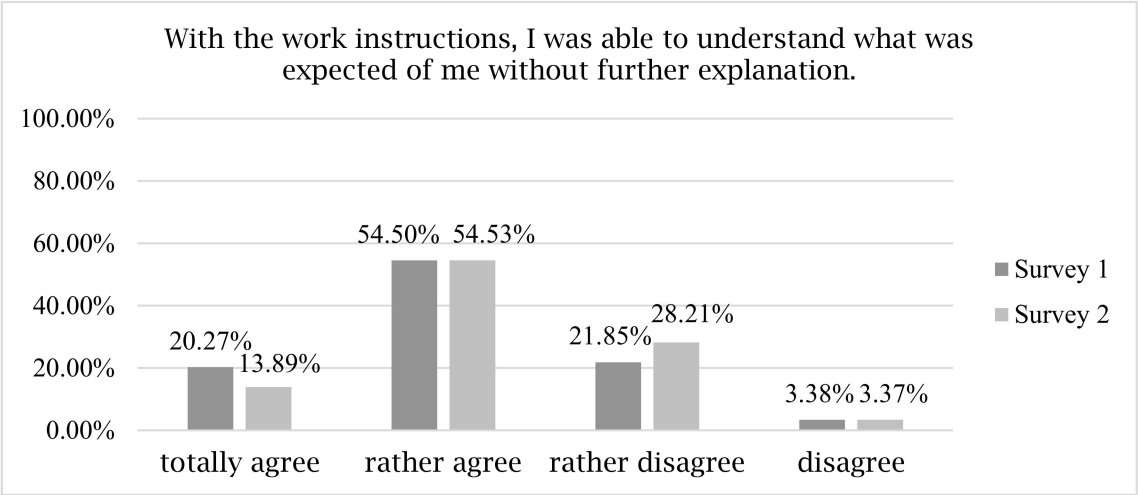

Figure 1. Students' perceptions pre- and post-intervention for problem openness.

Regarding the characteristic "situation orientation", when revising the tasks, it was ensured that the learning tasks did not repeat the theoretical scientific treatises of the lectures, but that the learning tasks represented complex professional situations. Consequently, a one-to-one transfer of the lecture contents to the learning tasks was no longer possible; students first had to transform lecture content into job-related contents. The study showed the associated change in contextualisation with a significant ($p < 0.05$ *) change in the mean value of the question as to whether the lecture content could be applied to the tasks, from 1.74 (survey 1) to 1.84 (survey 2) (four scale: 1 totally agree/4 disagree; see Figure 2). The business contextualisation of the learning contents required an increased transfer ability of abstract lecture contents into situated learning tasks. The comparison of the mean values between the two surveys showed that the tasks required an increased transfer ability of the students. In comparison to the first survey, the students found it more difficult to apply lecture content to situational learning tasks in the second survey.

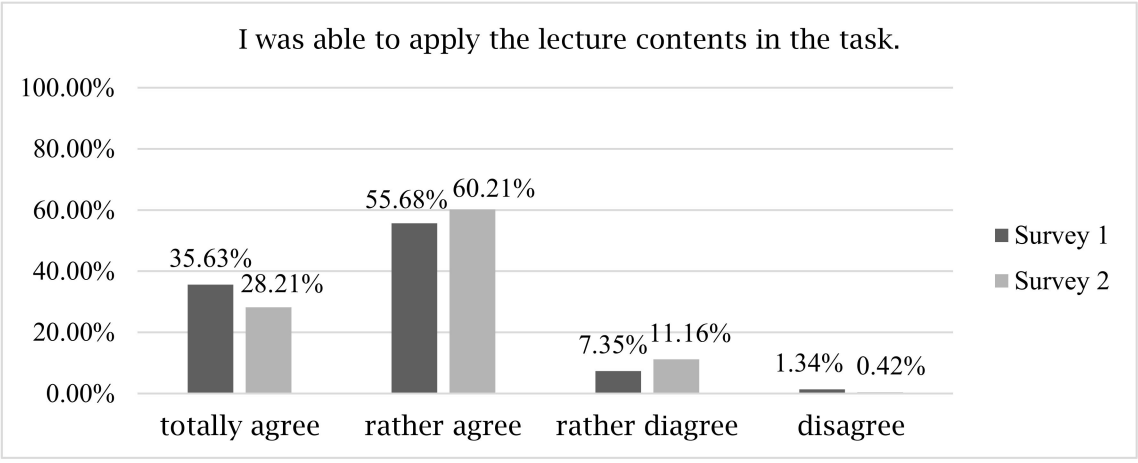

Figure 2. Perception of students pre- and post-intervention for situation orientation.

For increasing the openness of solution paths, the narrow specification of solutions, for example, through small-step work instructions, was reduced. At this point, students were asked to derive and justify their own solutions. Here the question was asked as to whether the students could work on the tasks according to their own solution. There was a

significant change ($p < 0.05$ *) from 2.34 (survey 1) to 2.44 (survey 2) after the intervention (scale of four: 1 totally agree/4 disagree; see Figure 3). It is astonishing that despite the increase in the openness of the solution paths, the students responded that they could not develop their own solution path. This result could be explained by discussion of the results of the tasks during the courses, especially if lecturers only discussed one solution path.

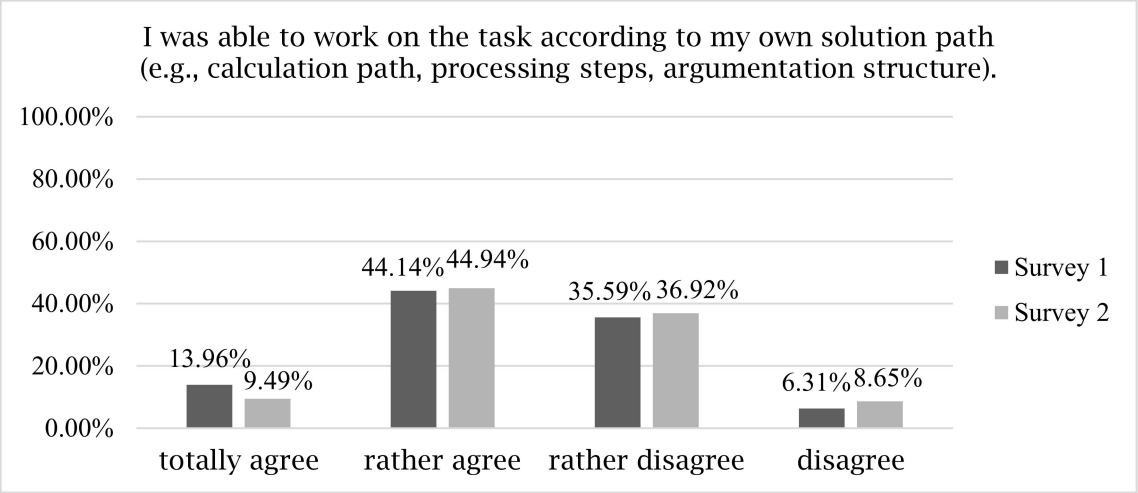

Figure 3. Students' perceptions pre- and post-intervention in terms of openness to solution paths.

In order to challenge the students' thought processes, and to increase the degree of difficulty of the learning tasks, the intervention raised the cognitive level of those tasks that were limited to reproducing what had been learned. Tasks that required problem solving were used more frequently. Regarding this characteristic, 29.25% of the learning tasks in the first survey, according to the student perception, were distributed as follows: 29.25% of the tasks were to reproduce only what had been learned, and 32.19% required an understanding of the contents first so that the tasks could be solved. Only 27.32% of the tasks were conceived in such a way that one had to apply the contents to an existing problem, and only 12.47% required one to acquire additional knowledge. The survey after the intervention shows that the adjustments of the learning tasks led to a significant change in the perceived cognitive level compared to the first student survey. Here, a reduction of 6.16 percentage points indicating tasks requiring the exclusive reproduction of what was learned, was measured, from 29.25% (survey 1) to 23.09% (survey 2) ($p < 0.001$ ***). On the other hand, the proportion of tasks that required an understanding of the content in order to be able to solve them increased significantly ($p < 0.001$ ***) from 32.19% (survey 1) by 4.57 percentage points to 36.76% (survey 2). A significant shift in the other two areas: "applying content to a given problem" and "acquiring additional knowledge" could not be measured (see Figure 4). It may be difficult to make a distinction at this level from the students' perspective. The before and after studies show that students perceive the increased cognitive level as being significant. In summary, the adaptation of tasks led to a shift in the cognitive level from "memorising" to "applying".

Another method of increasing the difficulty of learning tasks is through the utilization of the characteristic of linguistic complexity. During the intervention, the presentation of information in the learning tasks was revised. Mathematical indicators were transformed into vocational units and information was presented according to situational logic instead of the logic of the solution path, so that relevant information for accomplishing the task was not always clear and could only be identified through analysis. For the investigation, the question was asked as to whether students could extract from the task the information necessary for the task's processing. The study's result showed a significant ($p < 0.05$ *) increase in the mean value from 1.73 (survey 1) to 1.83 (survey 2) (four scale 1 totally agree/4 disagree; see Figure 5). The increased complexity of the linguistic logic meant

that the students were not always able to clearly extract the information necessary for processing from the tasks, compared to the initial survey.

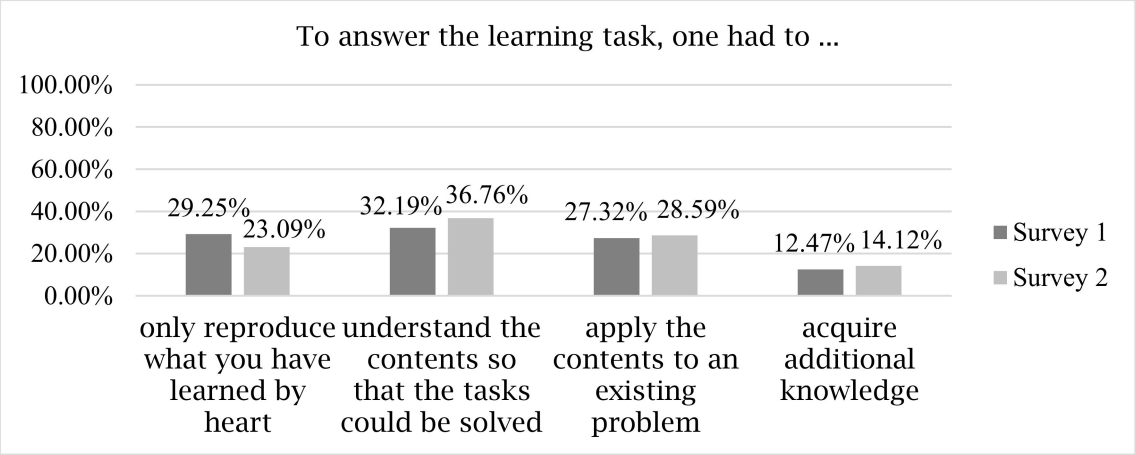

Figure 4. Students' perceptions pre- and post-intervention of the cognitive demands of the tasks.

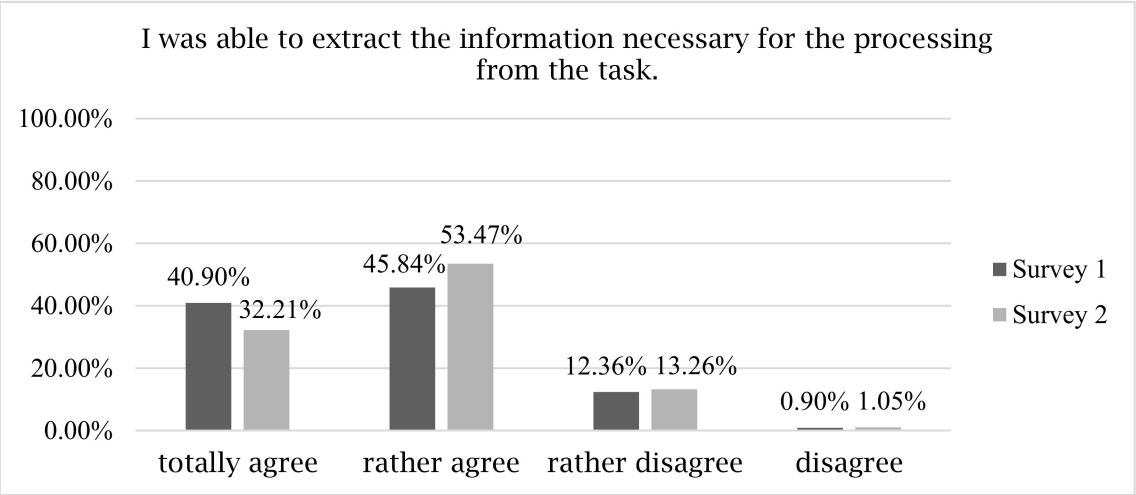

Figure 5. Students' perceptions pre- and post-intervention of complexity.

Furthermore, for the investigation of the characteristic "degree of difficulty", respondents were asked about their direct perception of the degree of difficulty. The comparison of answers in the two surveys to the question: "I find the degree of difficulty of the tasks is appropriate", showed that with the degree of difficulty of the learning tasks a significant shift of the mean value ($p < 0.05$ *) from 1.9 (survey 1) to 2.01 (survey 2) by 0.11 points can be determined (scale of four: 1 totally agree/4 disagree; see Figure 6).

In addition to questions about how the tasks were handled, the motivation to learn more about the subject area was also questioned. Despite the additional time required, and the perceived increase in the complexity of the content and the difficulty of the tasks, it was possible to determine an unchanged motivation (see Figure 7).

The increased level of difficulty was also reflected in the time required to solve the tasks. On a scale of four (in which 1 corresponds to less than one hour and 4 to more than 4 h) the time required increased significantly ($p < 0.001$ ***) by 0.24 from 1.77 (survey 1) to 2.01 (survey 2). Students required more weekly learning time to solve the tasks than before the learning task adjustments (see Figure 8).

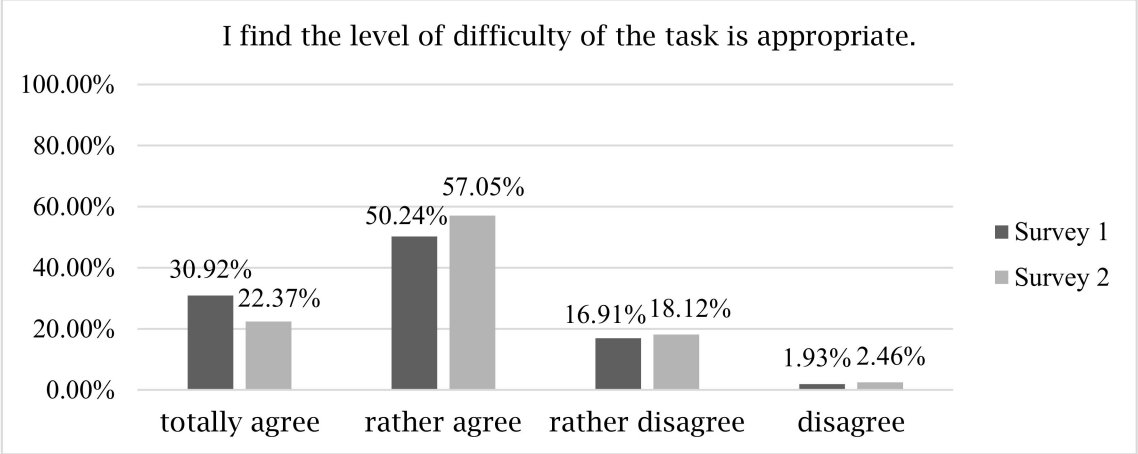

Figure 6. Students' perceptions pre- and post-intervention on the degree of difficulty.

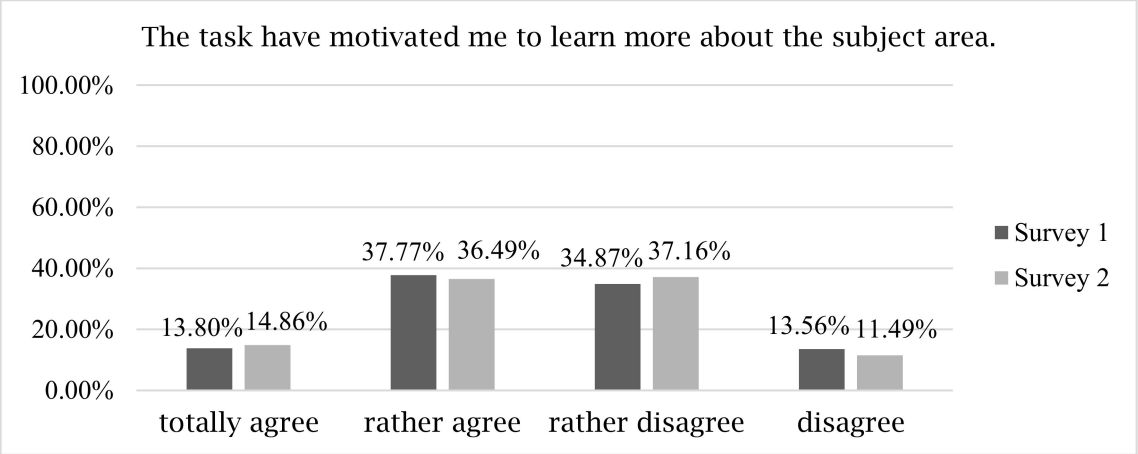

Figure 7. Perception of students pre- and post-intervention for motivation.

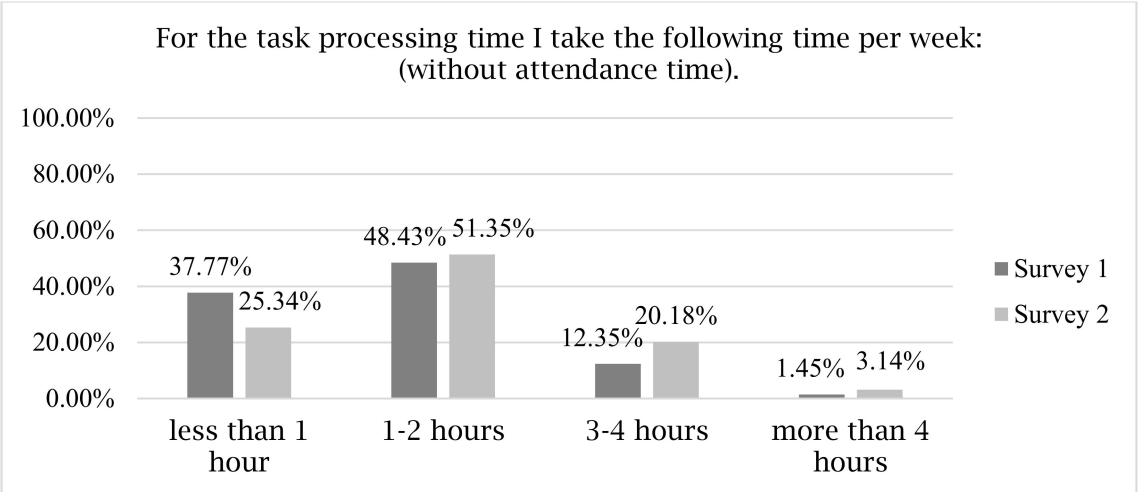

Figure 8. Time required to process the pre- and post-intervention tasks.

Table 2 gives an overview of the items with ordinal scales in the first and second survey.

Table 2. Overview of the items with ordinal scales in the first and second survey without the variable "cognitive demand".

	Survey 1		Survey 2			
Variables	**m**	**SD**	**m**	**SD**	***p***	**Level of Significance**
Problem openness	2.08	0.74	2.21	0.70	0.008	$p < 0.01$ **
Situation orientation	1.74	0.65	1.84	0.62	0.024	$p < 0.05$ *
Solution openness	2.34	0.80	2.44	0.76	0.033	$p < 0.05$ *
Complexity	1.73	0.72	1.83	0.68	0.031	$p < 0.05$ *
Degree of difficulty	1.9	0.75	2.01	0.67	0.029	$p < 0.05$ *
Motivation	2.48	0.92	2.44	0.89	0.618	$p > 0.05$
Time required	1.77	0.71	2.01	0.76	0.00000334	$p < 0.001$ ***

The mean values of the survey results of the learning tasks are mostly in the positive range of the scale showing that the students' handling of the learning tasks is definitely conducive to learning.

5. Discussion and Conclusions

The results show that working through the learning tasks enhanced by the increase of the characteristics problem openness, situation orientation, openness of solution paths as well as degree of difficulty, requires the more intensive involvement of the students. However, the before and after survey shows that despite the increased complexity and workload, the motivation to deal with topics of the subject has remained stable.

This could be as a result of the fact that the learner-centred, constructivist-orientated learning tasks now activate the learners' self-regulation more strongly. The increased complexity led initially to an excessive demand on the learners because they were not used to working on constructivist-orientated tasks. The study by Tremblay, Leppink, Leclerc, Rethans, and Dolmans shows that complex tasks produce a higher cognitive load and require more working time than a simple task; a lack of problem-solving experience and information research experience hinders the thinking process and results in a poorer self-assessment of performance. Complex tasks, however, strengthen reflective practice during debriefing. Students indicated that they learned more from the complex tasks [33].

Perkins [34] already mentioned three challenges that learners face in learner-centred, constructivist learning environments. The first is the cognitive complexity of the learning environment, which can lead to an initial cognitive overload of learners. Second, the increased demand on task management skills is described. The learners do not receive pre-defined solutions and must now activate their own task management skills. This ability can be developed in different ways depending on the learning culture and learning level of the learner. Thirdly, Perkins [34] shows that the constructivist-orientated learning environment contains two learning goals at the same time. On the one hand, students should acquire professional competence; while, on the other hand, they should also independently control the learning process for the acquisition of professional competence. A more recent study by Kyndt, Dochy, and Cascallar, on the context of learning tasks and subjective perception of students also confirms this effect [31].

At the same time, the results of the surveys also show that complex learning tasks motivate students to deal intensively with realistic and complex issues in a self-directed manner [35]. In this context, an initial overload can be prevented by an appropriate support system, such as scaffolding and coaching [34].

In general, the transition from traditional tasks to those designed along constructivist lines should be carried out step-by-step by the instructors. The changed expectations of students' learning behaviour must be clearly communicated and introduced by a support system [11,34]. In this context, the discussion of tasks must also be open so that the students' self-determination is required [9]. According to Jonassen [22], constructivist-orientated university teaching does not necessarily require small seminars with group work and discussions. More important is the development of concrete support tools for the students.

Nevertheless, it must be emphasised that the use of constructivist-orientated learning tasks alone is not sufficient to change learning culture. For this to happen, the university needs a holistic concept in which method of performance assessment is also constructivistic. This is because learning successes acquired through constructivist methods cannot be fully captured by the traditional performance assessment of knowledge acquisition at the lower-order level, leading to "sham constructivism" [6]. Against this background, the culture of performance assessment must be reconsidered so that constructivist-orientated learning methods can be fully effective. Instead of conducting a traditional written examination at the end of a learning unit, it is more appropriate to use learning portfolios, learning reports, and so forth [6].

Finally, the limitations of the study should also be pointed out. For example, only a single intervention in a university was analysed here. The learning process itself was not examined either, in other words, no teaching visits were made. Furthermore, no statements can be made about the actual learning success of the students due to the new task types.

Despite these limitations, the findings show that the introduction of constructivist-orientated learning tasks must be accompanied by the introduction of a constructivist-orientated learning culture into the university landscape. This intervention study is significant because the use of learning tasks shows a possibility to also enable constructivist learning in the context of large-scale courses where project work is not possible. The students' perceptions give evidence on how the use of learning tasks can be adapted.

The results can be transferred beyond business studies to other academic disciplines where the reconstruction of knowledge and the transfer of knowledge to the professional context is important, such as in the field of teacher education.

Against this background, this study contributes to research on the use of learning tasks from a student's perspective. The implementation of a constructivist-orientated teaching and learning culture must focus both on the people who prepare the knowledge and those who learn it.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

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Conflicts of Interest: The author declares no conflict of interest.

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education sciences

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Review

The Soft Skills of Special Education Teachers: Evidence from the Literature

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Abstract: The special education teacher is a key element in the development of the process of inclusive education. In this setting, soft skills have proven to be determinant in teachers' educational action. However, those that best qualify their profile have not yet been identified. Therefore, this study aims to carry out a review of scientific production between the years 2010 and 2020. To this end, articles were selected using the following databases: ERIC, Scopus, Web of Science, and PsycINFO. Studies have been included in the review that point out as soft skills: resilience, reflexibility, empathy, collaborative work, self-efficacy, creativity, and effective communication. Only studies that presented such criteria were included in the analysis. After the application of the eligibility criteria, seven articles were considered. From the analysis, it emerges that effective communication, collaborative work, and reflexibility stand out. There are gaps in this area in the specialized training of these teachers. Thus, it is suggested that there should be investment in this area in the training programs of the schools that certify them; and that, at the research level, instruments should be developed to evaluate the model emerging from this review.

Keywords: soft skills; inclusion; teachers of special education; teacher profile; effective communication

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1. Introduction

In addition to the major changes that have taken place in education systems around the world, innovation has also taken place regarding special education. In terms of the development of policies and practices at world level, inclusive education is one of the themes increasingly discussed [1–3]. For this reason, we currently use the best resource for a quality and equitable education: inclusion [2–5]. At world level, it has gone through moments of great change, partly thanks to the actions developed by UNESCO, previously proclaimed by the declaration of Salamanca on 10 June 1994 and also reiterated by the Universal Declaration of Human Rights of 1948, indispensable for the understanding of the development of inclusive education [6,7]. According to this organization, it is an "enriched form of general education aimed at improving the lives of those who suffer from various disabilities, enriched in the sense that it uses modern pedagogical methods and technical material to remedy certain types of disability" [8–10]. As Casanova [11] (p. 16) adds, it is "the provision and application of precise educational resources for all pupils, whatever their personal educational difficulties and needs, to achieve optimal individual and social development".

In the Portuguese educational context and in accordance with the Basic Law of the Education System [12], it constitutes one of the special modalities of school education "... dedicated to those persons who cannot follow the educational system temporarily or permanently under normal conditions" (article no. 19). In parallel with these changes, other changes have emerged, and the concept of disability has become a more comprehensive and non-stigmatizing concept, that is, the concept of special educational needs (SEN). The literature of the speciality reveals that the "inclusion" is currently designated to promote

ideas and practices, as well as formations that bring the school closer to an institution that lives in the values of inclusive education [1,13]. It is a relatively recent activity, which had its origins in a systematic way in the second half of the 19th century and which, until the sixties of the 20th century, developed an activity in the field of practical knowledge, of marginal action that resulted in a segregated character [14]. Today, a new vision of special education and of parallel activity has become an integral part of general education, constituting a special modality of education as it is inscribed in the "Lei de Bases do Sistema Educativo" (LBSE), of 14 October 1986, in Portugal. In recent decades, especially since the Salamanca Declaration [6], a new paradigm of an inclusive school, capable of welcoming and retaining groups of traditionally excluded children and young people, has been affirmed. This paradigm has evolved as a movement which ideally calls into question policies and practices of exclusion. Inclusive education thus aims at educational equity, which is the guarantee of equality in access, participation, and learning. In the framework of educational equity, the educational system and practices should ensure the management of diversity and adopt different types of strategies to meet the educational needs of students [15–19]. Inclusive education is education for all. It aims to reverse the path of exclusion by creating conditions, structures, and spaces for a diversity of learners, as proclaimed in the Salamanca Declaration in 1994, where it is stated that children and young people with special educational needs should have access to regular schools, which should be adapted to them through child-centered pedagogy, capable of meeting these needs [6].

Inclusive education thus reinforces the right of everyone to attend the same kind of education, guided by the principle of equal opportunities and education for all. It is a process that involves change and involves, among others: (i) valuing all pupils equally; (ii) increasing participation and reducing exclusion of pupils and cultures; (iii) restructuring policies, cultures, and practices in schools so that they respond to the diversity of pupils; and (iv) reducing barriers to learning and participation of all pupils regardless of their differences. This is an ongoing process of developing learning and participation for all pupils. According to Booth and Ainscow, it is an ideal that all schools can and should aspire to. Participation, according to the same authors, "means learning together with others and collaborating with them in shared educational experiences. This requires active involvement in learning and has implications for how the educational process is lived" [20] (p. 7). However, the inclusion policy for SEN students is based on factors that go beyond legislation. The question is how to make this heterogeneous reality compatible with schemes based on models not prepared to work on diversity and difference, on proposals from the perspective of homogenization [16]. The school will be inclusive when it transforms, not only the physical network, but the posture, attitudes and mentality of educators, and the school community in general, to learn to deal with heterogeneity and to live naturally with differences.

1.1. The Inclusive Teacher

The concept of inclusion or inclusive education is paramount and commonly associated with special needs education (so-called "EE") and special needs students [7]. It emerges in the context of the European Schools and the commitment to the education of people with disabilities in the regular education network, thus seeking to support the development of education systems, create schools that can respond to all children and young people and combat exclusion [21]. Inclusion involves change. It is a continuous process of learning development and participation of all students. It is an ideal to which all schools can aspire, but which will never be fully achieved. However, inclusion occurs as soon as the learning development process begins. An inclusive school is one that is on the move [20]. It requires a restructuring of schools to meet the needs of all children and another pedagogy within the classroom and another type of teacher. In this sense, an inclusive teacher, aside from recognizing the difference, adopts a pedagogy that includes everyone, seeking to provide a differentiated teaching, and he or she organizes the activities

and interactions in such a way that each one is often confronted with enriching situations according to his or her personal characteristics and needs.

By promoting the development of diversified strategies, the teacher becomes a facilitator, a true builder of learning environments that promote personal, cultural, and social development. He or she will have to develop and manage these environments by being flexible enough to deal with the unforeseen, the uncertainty, the expression of feeling, and the doubts and fears of those who grow up, along with those who learn. The teacher must go on forming, discovering, reflecting, adapting, identifying, and imagining new ways of acting that are more appropriate and closer to the realities with which he is confronted daily. The pedagogical differentiation appears as a path in the respect for difference by providing everyone with the same opportunities. To be able to differentiate, it is necessary not to be indifferent to differences. To teach a class, it is assumed that all students can learn, but in time and in their own way; that is, each learns certain knowledge according to their own characteristics, which come from their own knowledge and their habits of thinking and acting. Attention to individual differences, whatever their origin, in an inclusive school thus requires open and flexible curricula capable of responding to the common needs of the entire school population. Differentiation, adaptation, and individualization of curricula is necessary, in line with the needs and characteristics of each student. All pupils should have the same rights and opportunities, including the right to difference and an education adapted to their needs [16].

In this sense, the European Agency for Development in Special Needs Education (EADSNE) defines the profile of inclusive teachers and identifies four core values, related to teaching and learning, for the work of all teachers in inclusive settings: (i) valuing diversity—difference is considered a resource and a value for education; (ii) supporting all pupils—teachers have high expectations of outcomes for all pupils; (iii) working with others—collaboration and teamwork as essential methodologies for all teachers; and (iv) professional and personal development—teaching is a learning activity and teachers should take responsibility for their lifelong learning [22]. These values, presented as fundamental, together with their associated areas of competence are made up of three elements: attitudes (knowing how to be and how to live together), knowledge (knowing how to know), and abilities (knowing how to do). A certain attitude or conviction requires a certain knowledge or level of understanding and then abilities (know-how) to implement that knowledge in a practical situation. For each area of competence identified, the essential attitudes, knowledge, and skills that underpin them are presented.

1.2. The Profile of the Special Education Teacher

The special education teacher (so-called "PEE") in the Portuguese educational context constitutes one of the specific educational resources that, in the context of his specialty, supports, in a collaborative manner and in a logic of co-responsibility, the other teachers of the student in the definition of strategies of pedagogical differentiation and curricular accommodation, in the reinforcement of learning, and in the identification of multiple means of motivation, representation, and expression [1,23]. Thus, in addition to direct support (psycho-pedagogical support) in specific areas within its specialty, it provides indirect support or consultancy/mediation. His skills and profile have evolved and, if in the recent past, he was a teacher with a set of knowledge and skills that in schools facilitated the integration of pupils. Today, with the introduction of a new educational paradigm of integration for inclusion, this vision has changed. Thus, he began to direct his activity to all students with SEN whether they had disabilities [1]. Its competencies were first legally organized through a in five areas: critical analysis, intervention, training, supervision, and evaluation. However, this organization, according to some studies, proves to be little clarifying as each school interprets it in its own way. In this sense and for better clarification, the Association of Teachers of Special Education recommends that the competence profile of the PEE should be thought of in the perspective of establishing a bridge between the school we have and the school we want. It thus indicates a set of premises that define the

PEE as a collegial element of the school, a teacher who should cooperate with his colleagues, learning, teaching, and above all reflecting on what are the best models, frameworks, and materials to bring quality education to all students [1].

It should also, according to "Associação Nacional dos Docentes de Educação Especial" (ANDEE) [23], be: (i) a pedagogue who, within a pedagogical structure, is responsible for collecting, producing, and sharing information that is relevant to the education of all students; (ii) a professional in possession of intervention models that allow the school to understand, plan, execute, and evaluate inclusive models of pedagogical intervention; and (iii) a professional capable of articulating the internal and external services of the school, in a harmonic and coordinated whole, in order to achieve the best possible results. In this profile, PEE will be a professional with specialized training in one of its areas of expertise, a professional with scientific and practical knowledge in his area of expertise that will allow him to intervene, directly, in specific knowledge. Thus, for each student to progress in learning, they will essentially be a consultant, a collaborator, a supervisor, a facilitator, a co-operator, and a facilitator of practices that lead to success and quality in teaching. In short, he will be an inclusive teacher, as everyone should be, but specialized, contributing to our having a quality school where everyone learns according to their characteristics and abilities. In summary, he will be an inclusive specialist teacher, who in addition to his pedagogical and teaching skills, also known as hard skills, needs to be skilled in a set of personal and social skills that make for effective action. These skills are called soft skills.

1.3. The Soft Skills of the Special Education Teacher

The concept of soft skills has been considered in human resources, management, psychology, education, and the social sciences in general. However, some consensus has been found around the definition as a set of technical, methodological, and practical skills that is dynamically activated and manifested in performance [24–27]. Based on the concept of competence, it assumes the operationalization of a set of knowledge and attitudes in a specific situation in order to achieve specific results [28,29]. In turn, the concept of soft suggests the opposite of hard, hard skills referring to technical skills and soft skills to personal and social skills [30–32]. The concept of transferable skills is intertwined with that of soft skills, which are defined as "personality traits, goals, motivations and preferences that are valued in the labour market, at school and in many other fields" [33] (p. 451). Personal skills enable individuals to manage their own personal attributes, improve performance and sustain interpersonal relationships with others [28,33].

On soft skills, it should be noted that both the OECD and the European Union consider the development of their transversal skills to be relevant, and this is an area to be taken into account among the priorities of national training policies [33–36], being valued both in school and in the labor market and in social interaction in general. This relevance is justified by the fact that the degree of development of this type of skills predicts productivity at work, since they complement technical skills [37]. Thus, we can conclude that the challenges of the teaching career today can be more easily overcome by teachers with soft skills, in addition to the technical skills that are inherent to them. The OECD indicates the importance of teachers developing their transversal competences, and this is an area to be taken into account among the priorities of national training policies [34]. The European Commission, for its part, proposes that, in addition to promoting the development of these competences by teachers, they should also be developed by pupils, since their mastery leads to improvements in the overall teaching and learning process. This proposal is justified by the fact that these skills are acquired mainly through socio-emotional dynamics, hence the relevance of special education teachers developing soft skills in the training period as a way of enabling them to have a significant pedagogical presence in the educational community [38].

The empirical evidence also points to the fact that teachers' pedagogical capacities are related to their transversal competences, with those who possess these capacities proving to be more pedagogically effective than those who possess only theoretical knowledge [39].

Therefore, we can conclude that the challenges of the teaching career today can be more easily overcome by teachers qualified in the field of soft skills, in addition to the technical skills that are inherent to it, thus being able to effectively manage their daily tasks in challenging contexts, such as the one presented today to special education [40]. For all these reasons, the following question has been defined: what are the soft skills that special education teachers most need to be successful in their professional activity? Thus, this study aims to identify and describe the soft skills of special education teachers.

2. Methods

In order to find the answer to the above-mentioned question and achieve the objective of this study, a review was carried out, based on theoretical and empirical studies related to soft skills in the following databases: ERIC, Scopus, Web of Science, and PsycINFO. Studies were included in this review if they (i) involved special education teachers; (ii) assessed the soft skills, namely resilience, reflexibility, empathy, collaborative work, self- efficacy, and effective communication; (iii) were written in English, Portuguese, or Spanish; and (iv) were published in a peer-reviewed journal over the last 20 years. Therefore, keywords in search were soft skills and special education. A pair of researchers independently extracted relevant full papers. The discrepancies between the two main reviewers were resolved through discussion with a third co-author and a final list was obtained. As shown in Table 1, a total of 33 studies were identified. From these, 26 were excluded because they did not examine soft skills in special education teachers. All those focusing on students or other professionals such as psychologists or students were excluded.

Table 1. Summary of the initial screening *.

Authors	Q1	Q2	Q3	Q4	Non-Indexed Journals	Retention
Alexander and Byrd [41]					v	
Allala and Abusukkar [42]				v		
Bacon [43]	v					
Buehler, Comrie, Hofmann, McDonald, and Hurst [44]		v				
Burgess [45]			v			
Cantón and Garcia [46]				v		
Chong and Graham [47]	v					
Clark, Konrad and Test [48]	v					
Clark, Test, and Konrad [49]		v				
Connor, Sung, Strain, Zeng, and Fabrizi [50]	v					
Da Fonte and Boesch [51]					v	
Devereaux [52]				v		
Serrano, Dorrego Pupo, and Avila Guerra [53]					v	
Engelmann, Kappel, and Kerry-Moran [54]				v		
Espinoza, González, Castillo, and Neut [55]		v				
Guo, Dynia, and Lai [56]	v					v
Hemmeter, Hardy, Schnitz, Adams, and Kinder [57]	v					
Irvine [58]	v					v
Kart [59]		v				v
Mu, Hu, and Wang [60]	v					v
Nespor and Hicks [61]	v					
Peltier, Washburn, Pulos, and Peltier [62]		v				v

Table 1. *Cont.*

Authors	Q1	Q2	Q3	Q4	Non-Indexed Journals	Retention
Pickl, Holzinger, and Kopp-Sixt [63]	v					v
Rajoo [64]					v	
Rinta [65]	v					
Demirok, Gunduz, Yergazina, Maydangalieva, and Ryazanova [66]		v				v
Schechter and Feldman [67]	v					
Shealey, McHatton, and Wilson [68]		v				
Sullivan, Sadeh, and Houri [69]	v					
Tsaoussi [70]					v	
Voogt, Erstad, Dede, and Mishra [71]	v					
Wu-Pong, Gobburu, O'Barr, Shah, Huber, and Weiner [72]	v					
Yeni [73]	v					
Number of articles	15	7	1	4	6	7

* Note: Quartile rankings derived for each journal according to the SJR (Scimago Journal and Country Rank).

3. Results

The results obtained appear from selected articles in the ERIC, Scopus, Web of Science, and PsycINFO databases, published between 2010 and 2020 and in accordance with the inclusion and exclusion criteria previously defined and referred to above. All these articles were within the scope of special education, from the perspective of inclusion and with special attention to professionals in this field. The objectives of the selected articles referred to some soft skills, but in an isolated way, according to Table 2. Furthermore, in the theoretical basis, the studies revealed this dispersion of models and conceptions; hence the relevance of this study, which reveals itself to be innovative and useful, both for intervention and research in this area.

Table 2. Included studies that assess soft skills.

Quote	Resilience	Reflexibility	Empathy	Collaborative Work	Self-Efficacy	Effective Communication
Irvine [58]		V	V	V		V
Pickl, Holzinger, and Kopp-Sixt [63]	V	V		V	V	V
Mu, Hu, and Wang [60]	V					
Demirok, Gunduz, Yergazina, Maydangalieva, and Ryazanova [66]						V
Peltier, Washburn, Pulos, and Peltier [62]		V		V		V
Guo, Dynia, and Lai [56]					V	V
Kart [59]				V		
Number of articles	2	3	1	4	2	5

Table 2 illustrates the seven included studies. The data collected were presented according to the order of the date of publication, highlighting the type of journal and the skills analyzed by the different authors.

According to Guo et al. [56], in an article published in the journal Early Childhood Research Quarterly, in the quartile Q1 ranking, self-efficacy and effective communication skills are highlighted. Kart [59], in a paper published in the journal Education Sciences, in the quartile Q2 classification, highlights the skills of resilience and collaborative work. For Demirok et al. [66], in an article published in the International Journal of Emerging Technologies in Learning (IJET), in the quartile Q2 ranking, effective communication skills are highlighted. For Mu et al. [60], in an article published in Teaching and Teacher Education magazine, in the quartile Q1 classification, the competence of resilience is highlighted. According to Pickl et al. [63], in an article published in the International Journal of Inclusive Education, in the quartile Q1 classification, the skills of resilience, reflexibility, collaborative work, self-efficacy, and effective communication are highlighted. Finally, according to Irvine [58], in an article published in the Journal of Teacher Education, in the quartile Q1 rating, the skills of reflexibility, empathy, collaborative work, and effective communication are highlighted.

The article by Irvine et al. [58] addresses the issue related to multicultural education and special education and focuses on the complexity of the relationship between multicultural education and special education of African Americans, students of color as belonging to an identity category, usually identity related to their disability. The authors explored areas of divergence and conflict between the two areas—special education and multicultural education, specifically issues of disproportionate representation, cultural misunderstandings, tensions between home and school, and competition—providing some recommendations that can most effectively prepare special education teachers, namely culturally responsive pedagogy and training of special educators in developing caring relationships with students while maintaining high expectations; engagement and motivation of students; selection and effective use of learning resources; and promotion and learning with family and community involvement [58]. Thus, this article distinguishes itself by explicitly referring to reflectivity, and implicitly, empathy, collaborative work, and effective communication.

The article by Peltier [62] argues that the literacy process is complex for all children, especially those with learning difficulties. It requires that their teachers have deep, extensive and flexible knowledge about teaching these skills—phonological, phonetic, and orthographic awareness. This study addresses the fundamental knowledge, perceptions, and skills in this subject, as well as their reflexive capacity. It focused on a group of 12 teachers from general and special education preparation courses. The knowledge scores of initial and special education teachers were significantly higher from pre to post-tests and significantly different when compared in a general education literacy course. Reflective ability was not a significant predictor of primary school pupil growth and declined over time. The author thus explicitly presents the soft skills of reflexivity, and implicitly discusses collaborative work and effective communication.

In turn, the article by Pickle et al. [63] argues that today, special needs teachers need, in addition to general pedagogical skills, skills to manage highly heterogeneous groups in inclusive environments. This is a qualitative study, which aims to identify knowledge skills, action, and attitudes necessary for teachers to succeed effectively. In-service training, focusing on reflection and evaluation of individual and team work, as well as the reactions of students in initial special education training, can help increase the readiness to model a reflective attitude as a crucial prerequisite for teaching success. The results of this study therefore show that teachers need to improve their skills in reflexivity, resilience, reflectivity, collaborative work, and effective communication.

The article by Guo et al. [56] is a quantitative study, using a sample of 73 early childhood special education teachers and 837 preschool children. It aimed to verify the differences in the teaching of self-efficacy of children with and without disabilities, as well as the differences in the teaching of children with different types of disabilities. The findings of these authors indicate that the self-efficacy of teachers is a significant predictor of the knowledge acquired by children. In addition, they argue that poor teacher self-efficacy in

relation to children with disabilities may constitute an additional risk factor for the school maladjustment of these children. Thus, Guo et al. [56] focus their paper on the issues of effectiveness, including self-efficacy and effective communication.

Demirok et al. [66], with a qualitative study, used a sample of special education teachers in order to verify the opinions of special education teachers regarding the use of technology to assist students with reading difficulties. Although the focus of the study is on the use of technologies in teaching reading and writing, the results show that good communication is necessary in this process and that the technologies, in addition to saving time, provide the development of persistence and motivate and focus students' attention more. In this way, the soft skills that are evident in this study are effective communication.

The article by Mu et al. [60] focuses on resilience. This quantitative study, based on an ecological perspective, investigates the role of Chinese inclusive education teachers in the process of resilience of students with disabilities. The study shows that students with disabilities suffer from multiple stress factors, which requires a great ability to find adequate resources and minimize student difficulties, as the study demonstrates, summarizing all this into the competence of resilience.

In turn, Kart and Kart [59], in a literature review study, among the skills investigated, highlight the relevance of collaborative work in promoting inclusion and they state that this is one of the factors that most influence student outcomes in an inclusive school and that negative impacts can be mitigated with policies and active collaboration between all stakeholders in the educational process. In this way, the soft skill that is evident in this study are collaborative work.

The main results of these articles will be discussed below.

4. Discussion

The reduced number of publications in the ERIC, Scopus, Web of Science, and PsycINFO databases that address the soft skills of special education teachers in the inclusion process reveals the lack of studies in the area and the consequent need for research in this area. In our opinion, the profile of the special education teacher should include, besides the technical skills, inherent to its specialty group, the soft skills. In this sense, our study has identified a model of six soft skills that are now described and discussed. Therefore, in accordance with the above results, and responding to the research question presented, we found that some soft skills occupy a relevant place in the teaching performance of special education teachers, highlighting effective communication, collaborative work, and reflexibility.

These results are in line with those of Allala and Abusukkar [42], which affirm the importance of soft skills and the need to post them in order to be successful in professional life and that more attention should be paid to soft skills by teachers, particularly in their initial training and throughout their lives. Thus, we can conclude that soft skills are determinant in the access and performance of special education teachers' functions.

To lead the teaching-learning processes, all education naturally presupposes competence in the field of effective communication, which consists of making common, sharing ideas, exchanging information, and interacting [51,74,75]. Most of the articles reviewed have explicit references to effective communication [56,58,62,63,66]. For example, Irvine et al. [58] state that pro-teacher training institutions need to find strategies to empower all initial teachers to be effective educators, being persistent, open-minded, reflective, and therefore good communicators. Therefore, this soft skill implies a varied set of factors as it is a complex phenomenon. The human being, communicating at various levels, involves a varied set of factors that make it possible to express what one thinks, feels, and desires, choosing a set of attitudes appropriate to each situation, according to the place and the moment [26], and all this is fundamental in the context of inclusive education where the special education teacher acts. Thus, it is concluded that in educational interaction effective communication is essential to achieve the objectives of special education.

In addition to effective communication, special education presupposes collaborative work, which consists of planning, acting, and evaluating as a team. Some of the articles analyzed have explicit references to collaborative work [58,59,62,63], which is in line with those who argue that teamwork is essential in inclusive education [76–79]. For this reason, teachers need to improve their faculty of cooperation, which consists in the ability to "operationalize knowledge, attitudes and skills in order to act together, with a view to achieving a common goal by maximizing the potential of each individual in a durable and balanced way" [26] (p. 135). Promoting collaborative work in schools means highlighting the explicit intention of each one to add value to working together, contributing something different. Naturally, this type of action has been increasingly implemented since it is duly defined in the educational projects of educational institutions. Hence, we consider it to be an essential soft skill in the training and work of special education teachers.

Reflectivity is also essential in special education, since it is necessary to analyze, plan activities, and deal constructively with uncertainty and unpredictability in order to reformulate the action. The articles analyzed that explicitly refer to this capacity are Peltier et al. [62], Pickl [63], and Irvine [58]. To be successful in inclusive education also presupposes the use of reflexive thinking, as described in literature [80–82]. In this sense, Peltier et al. [62] state that reflective activities are widely used in teacher training programs. These activities are continuously developed in order to plan for the unpredictable circumstances of daily teaching.

This ability, according to the above-mentioned authors, manifests itself in the ability to ask and to doubt, to dialogue, and to criticize. In this sense, educational action requires systematic, rigorous, and strategic reflection on the emerging problems and the appropriate plans for their sustainable resolution. It is the very unpredictability of educational situations that demands the promotion of these reflective habits as a way of educating children, young people, and adults with special needs with quality. Thus, when someone joins an education team they even need to be equipped with practical knowledge about the techniques and methods to be creative and reflective in the context of the teaching-learning process itself.

Special education presupposes the competence of resilience. The articles that focus on this theme are Mu et al. [60] and Pick [63]. The special education teacher needs the competence of resilience to deal with the adversities that his or her profession inevitably raises [60,63]. This can be defined as "the ability to operationalize knowledge, attitudes and skills in order to prevent, minimize or overcome the harmful effects of crises and adversities" [26] (p. 167). Thus, a resilient teacher, having to face a stressful or adverse situation, is able to use his personal resources by assuming the behaviors that help him to be successful in that circumstance.

Successful inclusive teachers also manifest behaviour characterised by self-efficacy [83,84]. This soft skill was referenced in the articles of Guo et al. [56] and Pick et al. [63]. It should also be noted that others do not mention it explicitly but refer to it implicitly. According to Bandura [85], self-efficacy is related to beliefs about the ability to have self-control over individual behavior and events affecting life. It is this competence that facilitates decision-making in difficult situations, since it allows one to think and evaluate circumstances, to have self-determination and flexibility in order to effectively achieve the objectives previously outlined. These data are in line with the study by Guo et al. [56], which states that there is strong evidence that teacher self-efficacy in relation to each child is an important factor to be considered in the context of inclusive education. Therefore, this soft skill will therefore be necessary in the professional performance of the special education teacher.

Special education also presupposes the competence of empathy. Among the articles analyzed in this review, the one that focuses on this theme is that of Irvine [58]. The ability to listen actively to students is also essential in inclusive education [85]. Empathy consists in the ability to "listen in order to perceive the thoughts, feelings and intentions of the interlocutor, providing an adequate understanding of the situation expressed and encouragement for similar future situations" [26] (p. 80). Thus teachers, especially those in special education, need to develop this communication skill by improving not only

verbal communication, but also non-verbal communication. This accompanies the information exchanged, through looks, gestures, and smiles, which leads the interlocutor to feel understood, accepted, and encouraged.

Thus, according to the above, we can state that we have answered our research question, since we have identified six soft skills necessary for special education teachers to be successful in their activity. However, we recognize the limitations of this study.

It should also be noted that there are some limitations to this review, in particular the existence of little scientific production on this topic. Most of the articles focus on empirical work aimed at students and not at teachers. Moreover, the methodology of the study, an exhaustive analysis, was mainly descriptive but could have been accompanied by a meta-analysis.

5. Conclusions

The aim of this research was to contribute to the improvement of the subject in question by systematically reviewing scientific production between 2010 and 2020 to verify the soft skills most evident in this area of research. From the analysis of the articles and according to the selected soft skills—resilience, reflexibility, empathy, collaborative work, self-efficacy, and effective communication—we concluded that, although they emerge in isolation, effective communication, collaborative work, and reflexibility predominate. From the scarcity of literature in this field, and in the few articles found, no theoretical models were verified. Thus, there are some gaps in this area, not only at the level of scientific production, but also at the level of the specialized training of these teachers. As described in the literature, properly preparing professionals for these new roles and responsibilities requires the implementation of a new training model, since the challenges of the teaching career today can be more easily overcome with soft skills, in addition to the technical capacities that are inherent to it.

Within the framework of quality educational equity, education systems must not only ensure the management of diversity but also adopt a set of appropriate practices and strategies. In this context, the special education teacher has a leading role, for which they require not only innovative teaching and didactic practices and scientific knowledge inherent to his or her specialty group, but also a set of soft skills that can contribute to an inclusive education of quality and more effective. In this sense, in a truly inclusive school, its actors act with the development of all students in mind, and without the above-mentioned skills, their performance is limited, and the entire educational system is also impoverished. In the current context, the renewal of the profile of special education teachers increasingly requires the acquisition of transversal competencies that allow them to respond effectively to the challenges of schools that, by definition, must be inclusive, promoting equity, valuing diversity, teamwork, reflexivity, and resilience. It is therefore suggested that there should be investment in this area in the training programs of the schools that certify them, and that, at the research level, tools should be developed to evaluate the model emerging from this review.

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Article

Does Postsecondary Education Attainment Matter in Community Service Engagement? Evidence from Across 18 OECD Countries

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Abstract: This study is concerned with the central issues of community service engagement (CSE) in 21st century democratic societies around the world. To examine the factors influencing postsecondary education attainment's relationship to CSE, this study utilized data from the Organization for Economic Co-operation and Development (OECD) countries using ordinary least square (OLS) and two-level hierarchical linear modeling (HLM) methods, including various factors for each country's individual and country levels. The results show that attainment in postsecondary education at the individual level and investment and enrollments in tertiary education both have an influence on increasing CSE in 18 OECD countries. The present study is expected to contribute to an understanding of the relationship between postsecondary education and CSE across the world.

Keywords: postsecondary education; higher education; community service; civic engagement; educational attainment; OECD country; hierarchical linear model (HLM); PIAAC

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1. Introduction

Encouraging responsible, active, participatory citizenship is a goal in the field of education and has globally been an important agenda item among researchers, educators, and policy makers [1]. Increasing civic engagement is a growing concern, as it has been proven to be an essential aspect of high-quality governance and a well-functioning democracy, producing better quality schools, faster economic development, and more effective governments [2]. In Organization for Economic Co-operation and Development (OECD) countries, especially, matters of economic disparity and environmental sustainability have increased calls for a more civil society [3]. In terms of the relationship between a nation and its civic affairs, according to a Washington DC Gallup Poll [4], adults in developed countries are more likely to be civically engaged than those in the developing world. Furthermore, the related literature has revealed that civic engagement can be cultivated by a nation through its economic status, culture, or social norms [5,6]. Despite variances in civic engagement behaviors around the world, cultivating community service engagement and thereby increasing civic engagement is an important task for all global citizens [1].

In the United States, individuals express their beliefs in the importance of individual effort and concern for others through volunteerism and the ethic of service [7]. Americans believe that one of the ways of passing this value on to younger generations is to participate in community service [7]. According to U.S. Bureau of Labor Statistics [8], 24.9% of the total U.S. population volunteered at least once and spent average 52 hours on volunteer activities during the period from September 2014 to September 2015. The three main organizations people volunteered for were religious (33.1%), educational or youth service (25.2%), and social or community service-related organizations (14.6%) [8]. Thus, K-12 schools strive to play a crucial role in addressing community needs and often utilize service-learning as a

pedagogical method [9]. At the collegiate level, membership in Campus Compact, the U.S. coalition of colleges and universities committed to the public service purposes of higher education, grew from its founding three colleges in 1985 to over 1100 campuses in 2008 [10]. The increased pressure for educational accountability and commitment to public good has led universities to provide more opportunities for students to engage in community service and to learn through service-learning [11]. In addition to Campus Compact, a variety of professional and higher education organizations, such as the American Association of Colleges and Universities and the Engagement Scholarship Consortium, have been actively involved in community engagement in the United States.

Similarly, the United Kingdom places significance on building active citizens and believes that citizenship education is essential to achieving this goal [12]. Therefore, the national curriculum has included citizenship programs formally since 2002 with a goal to prepare students to become active, responsible members of society [13]. In the same manner, the majority of higher education institutions in the United Kingdom have been interested in promoting active citizenship, with an emphasis on volunteerism, so many institutions have provided various community service-learning programs for their students [14]. In addition, national organizations such as Volunteering Matters offer volunteer opportunities for the young generation.

In South Korea, the foundation of citizenship education has changed in accordance with Korean modern history from anticommunism in the 1950s (post-Korean war) to patriotism from the 1960s to the 1980s, to globalism and neoliberalism since the 1990s [15]. Recently, it has focused on preparing competitive workers rather than democratic citizens [15]. In K-12 education, community service activities are included in the formal school curriculum, so students tend to complete them mandatorily [16]. Korean higher education institutions do not seem to emphasize community service, so college students often participate in volunteer programs individually through non-profit organizations such as the Korean University Council for Social Service or religious organizations [17].

Last, surprisingly, citizens in South America show a relatively high level of civic engagement despite their countries' unfavorable political conditions and economic performances [18]. Citizens tend to actively participate in community activities to solve political and economic issues by raising their voices together [18,19]. The results of a survey of young teenagers from Chile and Columbia also revealed their civic engagement to be higher than the international mean, in spite of lower civic knowledge and attitudes [20]. In particular, various social and political issues in Chile have made universities' social responsibilities significant [21]. In 2001, many universities participated in the University Builds Country project to fulfill their responsibilities through service-learning [21].

As these countries have tried to expand their efforts for improving civic engagement, scholars and researchers also have revealed the relationship between education and civic engagement. In terms of the relationship between higher education and civic engagement (including community service engagement), past studies have focused on the connection between them and pointed out the importance of education in improving attitudes toward citizenship, civic education, political behavior, and social engagement [22–24]. Braskamp [25] also suggested that higher education should reinvestigate its role in preparing citizens for participation in a democratic society and the larger community. Since the 1970s, the field of postsecondary education has considered community service to be one of the most indispensable components of civic engagement and recognized its importance in student community service activities [26].

Although the importance of civic knowledge and engagement in the context of academia and society is convincing, thus far few empirical studies and trials have attempted to navigate the factors or determinants that influence community service engagement (CSE). There was particularly a dearth of recent empirical evidence from cross-national samples on the relationship between postsecondary education and CSE. This study, therefore, investigates how individual and national factors influence CSE. It focuses on the educational context, especially the influence of postsecondary educational (throughout this paper, the

terms higher education, postsecondary education, and tertiary education are regarded as concepts that can be interchangeable; however, we keep the original term from the given secondary datasets from each source) attainment at the individual and country levels within the OECD countries, using cross-national representative data and ordinary least square (OLS) regression and hierarchical linear modeling (HLM) methods. The specific research questions are as follows:

1. Does the level of CSE vary by educational level in OECD countries?
2. To what extent does individual educational attainment, especially postsecondary education attainment, affect CSE in each OECD country while controlling individual-level covariates?
3. To what extent does postsecondary education attainment at the country level directly affect CSE while controlling for both individual-level and country-level covariates?

Literature Review

There is no single definition of civic engagement. It is sometimes defined narrowly, to focus on one specific perspective and activity, or broadly, to cover "all activity related to personal and societal enhancement which results in improved human connection and human condition" [27] (p. 22). However, generally it refers to "the ways in which citizens participate in the life of a community in order to improve conditions for others or to help shape the community's future" [5] (p. 236). Civic engagement has four key aspects: community service, collective action, political involvement, and social change [5,27]. The first aspect, community service, focuses on individual or group participation and engagement in voluntary service activities in the local community [28]. Taking collaborative and collective action with other community members to advance their common interest is a significant feature of civic engagement as well [29]. Civic engagement also includes active participation and involvement in the political process or democracy [22]. Lastly, civic engagement should strive towards positive social change, which benefits the entire community [30]. Therefore, various activities are often considered forms of civic engagement (e.g., community problem solving, volunteering, fund-raising, voting, protesting, submitting petitions, and canvassing) [22].

To promote students' meaningful, experiential, and active learning and to prepare them to become the leaders of our future society, higher education institutions have been offering service-learning opportunities for students participating in service activities as components of course work or extracurricular activities [11]. Service-learning should closely relate to students' academic curriculum; experiences that a student obtains from service-learning need to meet the learning objectives of a certain course the student takes [11]. Therefore, unlike volunteerism, which more focuses on the receipient than the provider of volunteering, service-learning focuses on the development of students' learning through community service activities [11].

Emphasis on these activities in higher education institutions has naturally led to individuals in their 20s reporting higher participation in such activities than did previous generations [31]. Moreover, because a majority of colleges have begun to include community service experiences among their admission criteria, middle and high school students are participating in such activities at rates higher than those found among any other age groups, with numbers increasing steadily since the 1990s [5,32]. College students' participation in community service activities is especially important because people with prior volunteer experiences tend to remain involved in other forms of volunteer work continuously as they get older [26]. It seems that higher education institutions are the dominant gateway to promoting civic engagement among the youth in the long term.

Several studies have reported various benefits arising from students' service-learning experiences [11]. Through these experiences, students can improve their academic learning and develop practical skills [33]. They also provide opportunities for both personal growth (e.g., development of interpersonal, communication, problem-solving, and leadership skills) [34,35] and increased connections with their local community [36]. They are espe-

cially useful and critical in learning about diversity, because students' prejudices can be challenged by direct encounters with people with different identities (e.g., generations, socioeconomic status, ethnicity, and race) [37,38]. In addition, students can develop the capacity to be responsible members of society [35,39]. These activities also benefit students' future career by providing time to identify their values and consider career paths beneficial to their community [11].

Prior studies also identified an individual's motivations toward community service engagement, including altruism, patriotism, values, career, and enhancement [40–42]. Generation Z, who were born in the mid-1990s to 2002, especially seem to engage in community service activities to receive learning opportunities and to be beneficial for their career preparation [40]. Moreover, some scholars reported a close relationship between an individual's motivation to work in public sectors, such as government and non-governmental organizations (i.e., public service motivation) and engagement of community service activities, including volunteering [43,44]. In particular, people with a high level of commitment to the public interest tend to volunteer more often than others, and those people usually volunteer for political, religious, and charitable organizations [44].

In previous studies, background characteristics, such as gender, age, and religion, have been associated with engagement in community service [12,20,45]. These associated variables can be divided into three groups. First, as a proxy of economic capital, family background factors such as income have been reported as important attributes [12,45]. Second, as a proxy of social capital, parental education, occupation, and volunteer experience [45,46], along with the degree of social trust [47] and the service orientation of an individual's acquaintances [46,48], has correlated to CSE. Third, as a proxy of cultural capital, activities such as reading a book, going to a museum, or watching television news [20] and community organization experiences [31,32] have been associated with CSE. Other factors associated with the national level, such as characteristics of the individual's community [45] and governmental factors, such as media and ICT influence [49] or internationalization [50] also have an influence on CSE. Some studies also addressed education as one of the factors related to CSE; for example, the level of education, the desire for higher education attainment, and the availability of literacy resources at home are positively related to one's attitude towards civic engagement and CSE [20,51,52]. However, these studies were published almost 20 years ago, and there is still a dearth of recent literature examining the relationship between education, specifically focusing on postsecondary education, and CSE across OECD countries.

Comprehensively, even though postsecondary education has been gradually more interested in civic engagement and has put efforts into developing the curriculum and activities for community service, most previous studies focused on the individual factors influencing CSE and did not sufficiently consider educational factors using recently published large-scale data. Further, few trials have been conducted with a global perspective, and several studies were limited to a sample of one or a small number of countries. Thus, the conceptual model for our study, with literature support, is described in Figure 1.

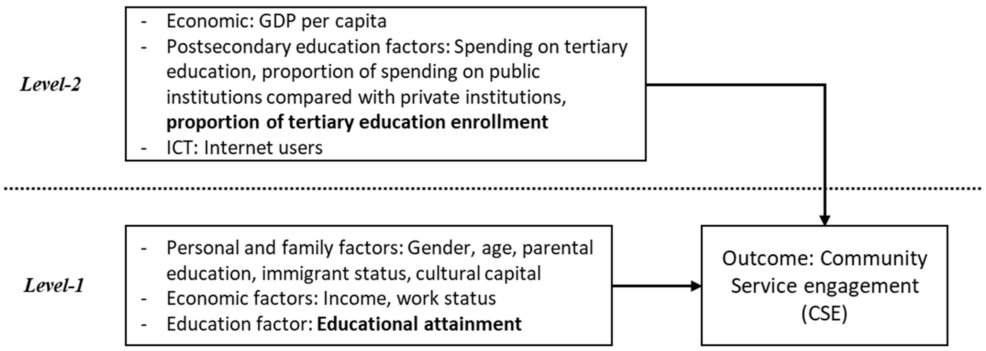

Figure 1. Conceptual model of predictors influencing community service engagement

2. Materials and Methods

2.1. Data and Sample

The data for this study came from the Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC), which assesses and compares the basic skills and competencies of adults in the 21st-century around the world. The survey was a large-scale study developed by the OECD, which surveyed 24 participating countries in 2012, nine additional countries in 2014, and another five in 2017. For this study, out of the 24 countries that were surveyed in 2012, 18 made their data available for public use. The surveys were conducted in multiple languages, all transcribed and subsequently translated so that the data could be available to the OECD in English. The raw data are organized by nation; thus, they had to be collapsed into one dataset. After the systematic missing values for a variable utilized for this study were deleted, the final dataset included a total of 110,288 individuals in 18 OECD countries. For the analysis, among 110,288 individuals, if there were missing data in a specific variable included in the analytic models, that observation was excluded from the analysis; thus, the number of individuals in OLS and the HLM model was 64,910.

2.2. Variables

The dependent variable of this study is CSE, measured by individuals' self-reported levels of participation in voluntary work. This includes unpaid work for a charity, political party, trade union, or other non-profit organization in the last 12 months. A Likert-scale was used for measuring the variable from (1) "never" to (5) "every day." It was redeemed as a continuing variable as often as possible so it could be used without any harm to the analysis [53].

Independent variables at the individual level (level-1) included personal factors, family background factors, economic factors, and educational factors. Personal factors included gender and age (16–55+). Family background included parental education (a proxy for social capital), the number of books at home (a proxy for cultural capital), and immigrant status. Economic factors included income level (a proxy for economic capital) and individuals' occupational status (e.g., student, employee, or retired). The educational factors that were used in the study included degree attainment (i.e., less than a high school diploma, high school diploma/some college but no degree, and college degree or higher).

In order to examine the effects of postsecondary educational attainment at the national level (level-2), other variables related to sectors of the economy, society, and technology were used as control variables, which were compiled from previous related studies [49,54,55]. The proportion of gross enrollment ratios in tertiary education for both sexes were used to assess postsecondary education attainment. In order to minimize the differences between the postsecondary education systems of each country, spending on tertiary education (1/1000 dollar) and the proportion of spending on tertiary education in the public sector were included as well. Gross domestic product (GDP) per capita (1/10,000 dollar) and the proportion of internet users were considered as control variables as well. All variables were drawn from indicators from World Bank and OECD data, aligning the same matched years (2012 and 2013) with the individual data from the PIAAC.

In the sample, in brief, 49% were female, 40% obtained greater than secondary education completion (postsecondary), 92% were employed or self-employed, and 89% were non-1st or 2nd generation immigrants. More specific descriptive statistics of the variables included in the analysis are presented in Table 1. It was confirmed that none of the missing data were biased towards a particular country or other variables.

Table 1. Descriptive statistics (n = 64,910).

Variable	Mean	Std. Dev.	Min	Max
Communivty Service Engagement (CSE)	1.63	1.00	1.00	5.00
Gender (female)	0.49	0.50	0.00	1.00
Age: 16–24 (Age1) *	0.13	0.33	0.00	1.00
Age: 25–34 (Age2)	0.23	0.42	0.00	1.00
Age: 35–44 (Age3)	0.24	0.43	0.00	1.00
Age: 45–54 (Age4)	0.23	0.42	0.00	1.00
Age: 55+ (Age5)	0.17	0.37	0.00	1.00
Lower than secondary education completion (ED1)	0.14	0.35	0.00	1.00
Secondary education completion (ED2) *	0.46	0.50	0.00	1.00
Greater than secondary education completion (postsecondary) (ED3)	0.40	0.49	0.00	1.00
Income: no income (Income1) *	0.15	0.36	0.00	1.00
Income: lowest quantile (Income2)	0.15	0.36	0.00	1.00
Income: next lowest quantile (Income3)	0.25	0.43	0.00	1.00
Income: mid-level quantile (Income4)	0.21	0.41	0.00	1.00
Income: next to highest quantile (Income5)	0.13	0.33	0.00	1.00
Income: highest quantile (Income6)	0.11	0.31	0.00	1.00
Immigrant status: 1st generation immigrants (Imgrt1) *	0.08	0.28	0.00	1.00
Immigrant status: 2nd generation immigrants (Imgrt2)	0.03	0.16	0.00	1.00
Immigrant status: non 1st or 2nd generation immigrants (Imgrt3)	0.89	0.32	0.00	1.00
Cultural capital: 10 books or less (Culture1) *	0.12	0.33	0.00	1.00
Culture capital: 11 to 25 books (Culture2)	0.15	0.35	0.00	1.00
Culture capital: 26 to 100 books (Culture3)	0.33	0.47	0.00	1.00
Culture capital: 101 to 500 books (Culture4)	0.18	0.38	0.00	1.00
Culturel capital: more than 500 books (Culture5)	0.22	0.42	0.00	1.00
Parental educaiton: Neither parent has attained upper secondary (ParEd1) *	0.35	0.48	0.00	1.00
Parental educaiton: At least one parent has attained secondary and postsecondary, non-tertiary (ParEd2)	0.41	0.49	0.00	1.00
Parental educaiton: At least one parent has attained tertiary (ParEd3)	0.25	0.43	0.00	1.00
Work status: Employed or Self-employed (Status1)	0.92	0.27	0.00	1.00
Work status: Retired (Status2)	0.00	0.07	0.00	1.00
Work status: Unemployed and looking for work (Status3) *	0.01	0.10	0.00	1.00
Work status: Student (including work programs (Status4)	0.04	0.20	0.00	1.00
Work status: Doing unpaid household work (Status5)	0.01	0.11	0.00	1.00
Work status: Others (Status6)	0.01	0.12	0.00	1.00
Proportion of Internet users (per 100 people) (C_Internet)	0.80	0.12	0.58	0.95
Average GDP per capita (10k) (C_GDP/capita)	0.41	0.22	0.14	1.03
Financial amount for tertiary education/student ($10,000)(C_TertiarySpend)	1.56	0.58	0.78	2.79
Proportion of spending on tertiary public education (C_SepndingTertiaryPublic)	0.73	0.21	0.32	0.96
Proportion of gross tertiary enrollment (C_TertiaryEnroll)	0.73	0.12	054	0.95

Note: Descriptive statistics indicate the analytic sample number is limited to 64,910, and the observation has no missing data across all the variables. In the table, * indicates the reference categories.

2.3. Analytic Methods

For the analysis of these data, the following three research hypotheses (alternative hypotheses) based on the aforementioned three research questions were established:

Hypothesis 1: *The level of CSE varies by educational level in OECD countries.*

Hypothesis 2: *Individual postsecondary educational attainment is positively associated with CSE.*

Hypothesis 3: *Postsecondary educational attainment at the country-level is positively associated with CSE.*

Specifically, for the first hypothesis test, we applied an ANOVA test with a Bonferroni post hoc test for multiple comparisons. Next, the second hypothesis was tested using OLS

regression. Lastly, hierarchical linear modeling (HLM) was utilized for the testing of the third hypothesis.

The rationale behind the use of the HLM method, in particular, is the fact that data can be commonly grouped by hierarchical level [56]. For example, in this study, the behaviors of people are influenced simultaneously by their personal backgrounds but also by their country of residence. This means that variances in outcome variables are shared by the hierarchically structured data, on both the individual and national level. HLM allows for the estimation of OLS regression, taking into account the nested structure of the data, a unit of measurement. Thus, HLM can use data clusters to avoid grouping errors [57], which is helpful for drawing out accurate estimate slopes for each level.

In terms of HLM modeling, first, specifically, we fitted an unconditional model (basic model) to examine whether the average CSE differs between countries. After that, we added individual-level variables, including individual educational attainment and other covariates (Model 1). Finally, country-level variables, including the portion of postsecondary enrollment and other covariates at the country level, were included (Model 2). In Model 2, all the regression slopes of individual predictors were fixed at the country-level (level-2), since the outcomes among the given OECD countries showed only relatively small variations. This was also done to methodologically secure statistical stability [57]. The final model (Model 2) can be briefly represented as follows:

(1) Level-1: $CSE_{ij} = \beta_{0j} + \sum_{p=1}^{5} \beta_{pj} Z_{\pi ij} + \sum_{p=6}^{13} \beta_{pj} Y_{\pi ij} + \sum_{p=14}^{23} \beta_{pj} X_{\pi ij} + \sum_{p=24}^{25} \beta_{pj} W_{\pi ij} + \rceil_{ij}$, $\rceil_{ij} \sim N(0, \sigma^2)$

(2) Level -2: $\beta_{0j} = \gamma_{00} + \sum_{c=1}^{5} \gamma_{0c} T_{cj} + \sqcap_{0j}, \sqcap_{0j} \sim N(0, \tau_{00})$

$$\beta_{pj} = \gamma_{p0}, \ (p = 1, 2, 3, \ldots, 25)$$

where CSE_{ij} is the CSE participation score for individual i in country j, β_{0j} is an intercept for j country, β_{pj} is the coefficients predicting CSE (W: educational attainment factors; X: economic factors; Y: family background factors; and Z: personal background factors), and $_{ij}$ is an error term to describe the unique effect of each individual. In addition, at level-2, γ_{00} is an average CSE, γ_{0c} indicates the coefficients predicting CSE, T_{cj} a>is country-level factors in the model, γ_{p0} is the average slope of the entire countries regarding individual-level variables, and $\sqcap_{0j}$ is the level-2 random effect which is the variation of differences between countries.

3. Results

Prior to conducting OLS regression and hierarchical linear modeling techniques, we examined the mean CSEs using a one-way ANOVA test with the Bonferroni post hoc test for multiple comparisons, which addressed the first research question. Means and standard deviations, as well as the results of the ANOVA comparison of means analysis, are set forth in Table 2. On average, CSE was 1.58 during the 12 months prior to completion of the survey. This value is between the level of "never (1)" and "less than once a month (2)". However, worldwide, CSE varies from 1.31 (Poland) to 2.04 (USA), which yields a standard deviation of 0.99 among the individuals sampled within the 18 OECD countries. An alternative hypothesis (H_1) predicts that for the individual participants in the CSE sample, CSE would be greater for individuals with higher rather than secondary education levels. As shown in Table 2, we rejected the null hypothesis, and the mean of CSE was not statistically equal for an individual with lower than high school completion, high school completion, and higher than high school completion. The detailed results of the Bonferroni post hoc test is also presented in Table 2. For those individuals with more than high school education (or postsecondary education level), the CSE in all 18 countries was higher than those with only high school completion or individuals with less than a high school completion.

Table 2. ANOVA results for differences in community service engagement (CSE) by educational level.

Country	CSE Mean	CSE Std. Dev.	Lower than High School Completion	High School Completion (Secondary Education)	Greater than High School Completion (Postsecondary Education)	*n*	Difference in Educational Level
All (18 countries)	1.58	0.99	1.43 (0.88)	1.53 (0.97)	1.75 (1.07)	110,288	F = 828.77 ***
Chile	1.55	1.01	1.47 (0.95)	1.53 (0.99)	1.70 (1.10)	5188	20.81 ***
Czech	1.35	0.83	1.35 (0.77)	1.32 (0.81)	1.46 (0.93)	6077	13.94 ***
Denmark	1.84	1.13	1.64 (1.04)	1.85 (1.15)	1.95 (1.15)	7284	41.55 ***
Estonia	1.43	0.82	1.30 (0.71)	1.39 (0.81)	1.53 (0.87)	7577	42.56 ***
Finland	1.77	1.03	1.59 (0.95)	1.77 (1.05)	1.89 (1.02)	5450	23.69 ***
France	1.53	1.03	1.26 (0.80)	1.47 (0.98)	1.70 (1.12)	6905	59.48 ***
Israel	1.73	1.09	1.55 (1.01)	1.71 (1.06)	1.89 (1.14)	5963	44.32 ***
Ireland	1.65	1.11	1.65 (1.13)	1.56 (1.06)	1.75 (1.14)	5308	15.23 ***
Italy	1.48	1.00	1.35 (0.89)	1.51 (1.03)	1.66 (1.12)	4584	26.98 ***
Japan	1.50	0.81	1.38 (0.73)	1.49 (0.80)	1.55 (0.84)	5172	12.16 ***
South Korea	1.44	0.83	1.44 (0.78)	1.40 (0.83)	1.48 (0.86)	6651	6.21 **
Norway	2.03	1.10	1.84 (1.03)	2.05 (1.11)	2.14 (1.12)	4941	29.67 ***
Poland	1.31	0.74	1.27 (0.62)	1.26 (0.69)	1.45 (0.88)	9360	53.32 ***
Slovakia	1.36	0.75	1.27 (0.66)	1.34 (0.73)	1.57 (0.89)	5695	49.20 ***
Spain	1.35	0.87	1.22 (0.72)	1.42 (0.94)	1.52 (1.01)	5970	70.71 ***
Sweden	1.70	1.06	1.48 (0.92)	1.71 (1.08)	1.80 (1.08)	4462	24.23 ***
United Kingdom	1.63	1.07	1.34 (0.86)	1.60 (1.05)	1.87 (1.17)	8806	181.47 ***
United of States	2.04	1.15	1.74 (1.09)	1.92 (1.12)	2.30 (1.15)	4895	87.30 ***

*** $p < 0.001$ ** $p < 0.01$. For these statistics, the sample is inclusive of observations suitable for analysis when the outcome variable has no missing values. The F-Statistic is calculated from variation between sample means divided by variation within the samples.

With regard to research question 2, whether educational degree level has a statistical influence on CSE when considering other factors associated with it, the results of the OLS regression are shown in Table 3a,b. According to the results, which included all individuals in 18 countries in the sample, individuals with post-high school degrees were more likely to participate in CSE than individuals with high school completion only ($\beta = 0.121$, $p < 0.001$), when considering other factors as constant. In terms of the results of a statistical model applied in each of 18 countries individually, the coefficients in 12 countries out of the 18 were statistically significant. However, all individuals with a postsecondary education level participated more in CSE than did individuals who had equal to secondary education completion in all 18 countries, holding other personal background characteristics, such as gender, age, immigrant and working status, and social, economic, and cultural capital constant.

In terms of the results from the HLM method for the last research question (see Table 4), the basic model was first run before the analysis. The indicator of the intra-class correlation coefficient (ICC) in CSE, calculated by dividing the between-country variance for the outcome variable by the total variance, turned out to be 0.055. This indicates that about 5.5% of the variability was caused by countries' individual factors or characteristics (in other words, accounted for by the between-country effect).

Table 3. Ordinary least square (OLS) estimates for educational attainment predicting community service engagement.

Variables	All Coef. (s.e.)	Chile Coef. (s.e.)	Czech Coef. (s.e.)	Denmark Coef. (s.e.)	Estonia Coef. (s.e.)	Finland Coef. (s.e.)	France Coef. (s.e.)	Ireland Coef. (s.e.)	Israel Coef. (s.e.)
Ed1	−0.137 ***	−0.086	−0.159 *	−0.150 **	−0.123 **	−0.179 **	−0.179 **	−0.238 ***	0.160 *
	−0.027	−0.065	−0.074	−0.051	−0.038	−0.06	−0.066	−0.07	−0.077
Ed3	0.121 ***	0.150 +	0.147 *	0.056	0.145 ***	0.048	0.147 ***	0.156 **	0.183 ***
	−0.023	−0.085	−0.074	−0.044	−0.03	−0.045	−0.04	−0.054	−0.052
Covariates (control variables)									
Age2	−0.158 ***	0.021	0.081	0.003	0.021	0.016	0.141 *	0.052	−0.052
	−0.041	−0.092	−0.076	−0.085	−0.046	−0.073	−0.055	−0.083	−0.065
Age3	0.021	0.129	0.094	0.322 ***	0.045	0.214 **	0.368 ***	0.290 ***	0.006
	−0.041	−0.098	−0.078	−0.086	−0.046	−0.076	−0.058	−0.085	−0.072
Age4	0.085 *	0.114	0.053	0.293 ***	0.083 +	0.262 ***	0.430 ***	0.616 ***	0.185 *
	−0.042	−0.104	−0.095	−0.086	−0.05	−0.078	−0.06	−0.095	−0.082
Age5	0.193 ***	0.105	0.051	0.204 *	0.023	0.206*	0.366 ***	0.516 ***	0.055
	−0.045	−0.115	−0.089	−0.085	−0.052	−0.081	−0.067	−0.101	−0.085
Female	0.053 **	0.055	−0.086	−0.161 ***	−0.100 ***	−0.080 *	−0.147 ***	−0.123 **	−0.034
	−0.02	−0.066	−0.058	−0.037	−0.029	−0.037	−0.034	−0.046	−0.044
Income2	−0.033	−0.387 ***	0.138	−0.266 ***	−0.096 +	−0.188 ***	−0.043	−0.077	0.028
	−0.034	−0.117	−0.094	−0.078	−0.052	−0.056	−0.105	−0.103	−0.091
Income3	0.013	−0.380 ***	0.11	−0.230 **	−0.099 *	−0.132 *	−0.077	−0.290 ***	−0.179 *
	−0.03	−0.114	−0.07	−0.078	−0.048	−0.055	−0.1	−0.079	−0.079
Income4	0.096 **	−0.398 ***	0.06	−0.206 *	−0.105 *	−0.061	−0.045	−0.261 **	−0.185 *
	−0.032	−0.114	−0.078	−0.082	−0.049	−0.058	−0.104	−0.081	−0.08
Income5	0.152 ***	−0.305*	0.137	−0.194 *	−0.172 **	0.013	−0.047	−0.180 *	−0.242 **
	−0.036	−0.15	−0.095	−0.089	−0.052	−0.068	−0.112	−0.092	−0.09
Income6	0.069 +	−0.519 ***	0.025	−0.219 *	−0.135 *	−0.019	−0.168	−0.284 **	−0.279 **
	−0.037	−0.135	−0.099	−0.094	−0.057	−0.072	−0.12	−0.096	−0.094
Imgrt2	0.087	0.127	0.036	0.16	−0.004	−0.107	0.189 *	0.145	0.329 ***
	−0.079	−0.562	−0.377	−0.168	−0.06	−0.348	−0.084	−0.185	−0.062
Imgtr3	−0.047	0.086	−0.294	0.208 ***	0.029	0.243 *	0.199 ***	0.397 ***	0.312 ***
	−0.038	−0.119	−0.235	−0.043	−0.046	−0.1	−0.049	−0.049	−0.051
Culture2	−0.007	0.116	0.046	0.031	−0.010	0.134 +	0.052	0.106	0.047
	−0.031	−0.076	−0.147	−0.079	−0.084	−0.08	−0.053	−0.072	−0.074
Culture3	0.105 ***	0.141	−0.051	0.075	0.011	0.079	0.127 **	0.173 *	0.120 +
	−0.029	−0.093	−0.118	−0.071	−0.078	−0.072	−0.048	−0.067	−0.067
Culture4	0.179 ***	0.216	0.171	0.045	0.079	0.252 **	0.181**	0.190*	0.144 +
	−0.036	−0.152	−0.136	−0.075	−0.081	−0.08	−0.061	−0.08	−0.079
Culture5	0.251 ***	0.564 **	0.138	0.149 +	0.123	0.291 ***	0.311 ***	0.184 *	0.463 ***
	−0.038	−0.21	−0.129	−0.076	−0.081	−0.08	−0.066	−0.082	−0.078
ParEd2	0.139 ***	0.071	−0.051	−0.041	0.058+	0.048	0.062	0.005	0.031
	−0.022	−0.07	−0.101	−0.044	−0.033	−0.043	−0.04	−0.052	−0.056
ParEd3	0.256 ***	0.018	−0.070	−0.031	0.130 **	0.024	0.074	0.116+	0.118 +
	−0.029	−0.103	−0.126	−0.053	−0.04	−0.058	−0.058	−0.066	−0.06
Status1	−0.153 +	−0.126	0.057	0.035	0.041	0.321 +	0.078	0.526 **	0.251
	−0.088	−0.158	−0.128	−0.196	−0.124	−0.177	−0.253	−0.201	−0.191
Status2	0.167	0.364	0.132	−0.037	−0.284 +	0.953 **	0.083	1.032 **	1.748 +
	−0.186	−0.506	−0.171	−0.273	−0.149	−0.32	−0.365	−0.375	−0.967
Status4	0.285 **	0.061	0.157	0.062	0.325 *	0.454 *	0.244	0.574 *	0.528 *
	−0.107	−0.196	−0.167	−0.209	−0.157	−0.194	−0.276	−0.232	−0.22
Status5	0.398 *	−0.330 +	−0.074	−0.422	−0.009	0.347 +	−0.19	0.227	0.573
	−0.165	−0.185	−0.163	−0.271	−0.151	−0.21	−0.266	−0.375	−0.472
Status6	−0.026	−0.174	−0.136	−0.173	−0.093	0.385	0.282	0.312	0.311
	−0.118	−0.235	−0.175	−0.233	−0.142	−0.242	−0.344	−0.287	−0.243
Constant	1.539 ***	1.722 ***	1.440 ***	1.678 ***	1.317 ***	0.974 ***	0.915 ***	0.709 **	0.929 ***
	−0.105	−0.244	−0.305	−0.214	−0.159	−0.218	−0.273	−0.219	−0.209
n	64,910	3025	3017	5137	4367	3668	3835	3256	2877
R^2	0.06	0.06	0.03	0.03	0.03	0.04	0.05	0.08	0.07

(**a**) Reference group: Age1 (16–24), Ed2 (secondary education completion), Imgrt1 (1st generation immigrants), Income1 (no income), Culture1 (cultural capital_lowest quantile), ParEd1 (neither parent has attained upper secondary), Status3 (not working and looking for work). + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3. *Cont.*

Variables	Italy Coef. (s.e.)	Japan Coef. (s.e.)	S. Korea Coef. (s.e.)	Norway Coef. (s.e.)	Poland Coef. (s.e.)	Slovakia Coef. (s.e.)	Spain Coef. (s.e.)	Sweden Coef. (s.e.)	UK Coef. (s.e.)	USA Coef. (s.e.)
Ed1	−0.022	−0.115 *	−0.140 ***	−0.198 ***	−0.065	−0.087 +	−0.217 ***	−0.109	−0.271 ***	−0.160 *
	−0.054	−0.047	−0.039	−0.05	−0.051	−0.049	−0.053	−0.071	−0.052	−0.075
Ed3	0.128 +	0.036	0.090 **	0.023	0.187 ***	0.211 ***	0.025	0.027	0.144 **	0.287 ***
	−0.071	−0.031	−0.032	−0.045	−0.044	−0.044	−0.056	−0.045	−0.046	−0.052
Covariates (control variables)										
Age2	−0.045	0.072	−0.083	0.094	−0.047	−0.054	−0.033	0.008	0.086	−0.232 **
	−0.092	−0.051	−0.054	−0.067	−0.037	−0.053	−0.075	−0.084	−0.066	−0.079
Age3	0.065	0.151 **	−0.002	0.506 ***	0.089 *	−0.015	0.122	0.314 ***	0.269 ***	0.015
	−0.093	−0.051	−0.055	−0.07	−0.043	−0.054	−0.079	−0.088	−0.07	−0.083
Age4	0.167 +	0.226 ***	0.138*	0.506 ***	0.098 *	0.049	0.089	0.335 ***	0.354 ***	−0.028
	−0.095	−0.056	−0.056	−0.072	−0.05	−0.056	−0.078	−0.089	−0.071	−0.084
Age5	0.089	0.363 ***	0.269 ***	0.234 **	0.125 +	0.049	0.250 *	0.209 *	0.298 ***	0.098
	−0.098	−0.059	−0.064	−0.075	−0.065	−0.061	−0.101	−0.09	−0.075	−0.09
Female	0.012	−0.134 ***	0.085 **	−0.140 ***	0.073 *	0.007	−0.066	−0.132 **	0.013	0.073 +
	−0.047	−0.032	−0.027	−0.038	−0.037	−0.028	−0.041	−0.042	−0.043	−0.043
Income2	−0.214 *	−0.092 *	−0.077 +	−0.059	−0.017	−0.076	−0.040	−0.483 ***	−0.398 ***	−0.322 **
	−0.085	−0.046	−0.044	−0.073	−0.062	−0.058	−0.058	−0.111	−0.089	−0.102
Income3	−0.074	−0.045	−0.034	−0.111	−0.020	−0.121 *	0.012	−0.251 **	−0.514 ***	−0.334 ***
	−0.086	−0.048	−0.04	−0.071	−0.062	−0.061	−0.062	−0.077	−0.089	−0.098
Income4	−0.048	−0.024	0.021	−0.121	0.016	−0.058	−0.024	−0.217 **	−0.515 ***	−0.282 **
	−0.091	−0.047	−0.043	−0.08	−0.074	−0.08	−0.067	−0.081	−0.091	−0.101
Income5	0.097	−0.068	0.037	0	−0.047	−0.020	−0.002	−0.266 **	−0.450 ***	−0.236 *
	−0.103	−0.053	−0.052	−0.087	−0.089	−0.188	−0.078	−0.087	−0.102	−0.105
Income6	−0.178+	−0.096+	0.063	−0.090	0.024	0.011	−0.082	−0.265 **	−0.430 ***	−0.310 **
	−0.107	−0.051	−0.057	−0.092	−0.091	−0.111	−0.086	−0.094	−0.105	−0.11
Imgrt2	0.134	0	−0.544 ***	0.367	−0.297	0.134	−0.068	−0.030	0.017	0.079
	−0.331	(.)	−0.112	−0.244	−0.256	−0.221	−0.129	−0.112	−0.107	−0.127
Imgtr3	0.026	−0.538	0.075	0.320 ***	−0.388 **	0.037	0.114 *	0.189 ***	0.087	0.112 +
	−0.073	−0.492	−0.103	−0.055	−0.118	−0.145	−0.049	−0.056	−0.058	−0.068
Culture2	0.118 *	0.045	0.097 *	0.029	0.034	0.055	0.053	0.028	−0.095	−0.051
	−0.06	−0.041	−0.038	−0.104	−0.052	−0.056	−0.055	−0.116	−0.075	−0.071
Culture3	0.250 ***	0.192 ***	0.150 ***	0.137	0.132 *	0.103 *	0.087	0.032	−0.014	0.167 *
	−0.065	−0.039	−0.036	−0.094	−0.052	−0.052	−0.057	−0.098	−0.07	−0.07
Culture4	0.356 ***	0.216 ***	0.247 ***	0.196 *	0.280 ***	0.127 *	0.184 *	0.1	0.064	0.259 **
	−0.084	−0.053	−0.051	−0.097	−0.068	−0.059	−0.08	−0.104	−0.08	−0.083
Culture5	0.511 ***	0.208 ***	0.288 ***	0.282 **	0.321 ***	0.207 **	0.229 **	0.264 *	0.125	0.425 ***
	−0.101	−0.055	−0.056	−0.097	−0.082	−0.066	−0.084	−0.104	−0.083	−0.086
ParEd2	0.011	−0.004	−0.001	−0.047	−0.049	−0.039	−0.018	0.006	0.067	0.003
	−0.063	−0.041	−0.032	−0.047	−0.059	−0.036	−0.055	−0.054	−0.052	−0.069
ParEd3	−0.104	−0.031	0.058	−0.043	−0.012	−0.048	0.06	0.019	0.216 ***	0.027
	−0.121	−0.046	−0.046	−0.056	−0.094	−0.061	−0.068	−0.055	−0.064	−0.077
Status1	−0.392	0.368 **	0.172+	−0.124	−0.010	−0.114	0.081	−0.108	−0.580	−0.050
	−0.316	−0.12	−0.089	−0.345	−0.083	−0.145	−0.075	−0.27	−0.422	−0.158
Status2	−0.294	0.814	0.591	0.249	−0.067	0.083	−0.437 **	0.073	−0.677	0.23
	−0.467	−0.501	−0.559	−0.543	−0.145	−0.27	−0.134	−0.401	−0.623	−0.332
Status4	−0.449	0.552 ***	0.251 *	0.045	0.323 **	0.185	0.211	−0.136	−0.283	0.257
	−0.375	−0.15	−0.127	−0.351	−0.119	−0.207	−0.188	−0.287	−0.447	−0.181
Status5	−0.907 **	0.613 **	0.285	0.114	−0.065	0.195	−0.172 *	−0.415	−0.932 *	0.716 *
	−0.339	−0.228	−0.197	−0.425	−0.212	−0.232	−0.088	−0.293	−0.47	−0.281
Status6	−0.461	0.142	0.152	−0.395	0.242	−0.286	0.224	0.278	−0.487	−0.082
	−0.343	−0.154	−0.128	−0.376	−0.217	−0.223	−0.212	−0.381	−0.455	−0.191
Constant	1.597 ***	1.457 **	0.903 ***	1.604 ***	1.474 ***	1.360 ***	1.137 ***	1.626 ***	2.165 ***	2.004 ***
	−0.339	−0.508	−0.149	−0.365	−0.157	−0.207	−0.122	−0.285	−0.437	−0.197
n	2396	3560	4219	3854	4339	2911	2799	3191	5225	3234
R^2	0.05	0.04	0.04	0.06	0.06	0.04	0.04	0.04	0.08	0.09

(**b**) Reference group: Age1 (16–24), Ed2 (secondary education completion), Imgrt1 (1st generation immigrants), Income1 (no income), Culture1 (cultural capital_lowest quantile), ParEd1 (neither parent has attained upper secondary), Status3 (not working and looking for work). + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Two-level hierarchical linear modeling (HLM) result of postsecondary educational attainment predicting CSE (n = 64,910 at Level 1; n = 18 at Level 2).

Fixed Effects	Basic Model Coef. (s.e.)	Model 1 Coef. (s.e.)	Model 2 Coef. (s.e.)
Constant	1.619 **	1.258 ***	0.969 **
	(0.055)	(0.069)	(0.257)
Level-1 Variables			
Female		−0.066 ***	−0.066 ***
		(0.008)	(0.008)
Age2		−0.016	−0.016
		(0.015)	(0.015)
Age3		0.149 ***	0.149 ***
		(0.015)	(0.015)
Age4		0.211 ***	0.211 ***
		(0.015)	(0.015)
Age5		0.182 ***	0.181 ***
		(0.016)	(0.016)
Ed1		−0.130 ***	−0.130 ***
		(0.012)	(0.012)
Ed3		0.117 ***	0.118 ***
		(0.009)	(0.009)
Income2		−0.122 ***	−0.122 ***
		(0.014)	(0.014)
Income3		−0.142 ***	−0.142 ***
		(0.013)	(0.013)
Income4		−0.114 ***	−0.114 ***
		(0.014)	(0.014)
Income5		−0.088 ***	−0.088 ***
		(0.016)	(0.016)
Income6		−0.107 ***	−0.107 ***
		(0.017)	(0.017)
Imgrt2		0.150 ***	0.149 ***
		(0.027)	(0.027)
Imgtr3		0.190 ***	0.191 ***
		(0.014)	(0.014)
Culture2		0.056 ***	0.056 ***
		(0.015)	(0.015)
Culture3		0.136 ***	0.135 ***
		(0.014)	(0.014)
Culture4		0.195 ***	0.194 ***
		(0.015)	(0.015)
Culture5		0.282 ***	0.281 ***
		(0.016)	(0.016)
ParEd2		0.007	0.007
		(0.010)	(0.010)
ParEd3		0.033 **	0.033 **
		(0.012)	(0.012)
Status1		0.016	0.016
		(0.038)	(0.038)
Status2		0.168 *	0.168 *
		(0.067)	(0.067)
Status4		0.205 ***	0.206 ***
		(0.043)	(0.043)
Status5		0.056	0.056
		(0.052)	(0.052)
Status6		0.001	0.001
		(0.050)	(0.050)

Table 4. *Cont.*

Fixed Effects	Basic Model Coef. (s.e.)	Model 1 Coef. (s.e.)	Model 2 Coef. (s.e.)
Level−2 Variables			
C_GDP/capita (10k)			0.780 ***
			(0.185)
C_Internet			−7.612 **
			(0.281)
C_TertiarySpend			0.164 **
			(0.063)
C_SepndingTertiaryPublic			−0.008
			(0.137)
C_TertiaryEnroll			0.455 *
			(0.209)
Random effects			
Between countries (τ_{00})	0.055	0.050	0.010
	(0.018)	(0.017)	(0.004)
Within countries (σ^2)	0.952	0.921	0.922
	(0.005)	(0.005)	(0.005)
Chi-square	3388.92 ***	2973.63 ***	367.38 ***

Reference group: Age1 (16–24), Ed2 (secondary education completion), Imgrt1 (1st generation immigrants), Income1 (no income), Culture1 (cultural capital_lowest quantile), ParEd1 (neither parent has attained upper secondary), Status3 (not working and looking for work. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Next, according to the results of Model 1, including level-1 predictors and covariates, individual postsecondary educational attainment was significantly positively associated with CSE compared to the secondary educational attainment ($\beta = 0.117$, $p < 0.001$). At the same time, less than high school completion attainment negatively influenced CSE, compared to secondary educational attainment ($\beta = -130$, $p < 0.001$).

Additionally, the result of Model 2 shows that, globally, individuals with more than a high school education were more likely to participate in CSE compared to those who had only completed high school ($\beta = 0.118$, $p < 0.001$), when other factors at the individual and country levels remain constant in the model. On the other hand, individuals who completed lower than secondary education were associated with lower participation in CSE than those who completed secondary education. Meanwhile, the proportion of the postsecondary education enrollment at the country level (level-2) was positively associated with increased participation in CSE ($\beta = 0.006$, $p < 0.05$) across the OECD countries as well, when holding spending on tertiary education, the proportion of public-sector to private-sector spending on tertiary education, GDP per capita, and the proportion of internet users constant in the model.

4. Discussion and Conclusions

Recent decades have witnessed a rising emphasis on civic engagement and citizenship, and it is recognized as the leading civic education movement. The issues of civic engagement in postsecondary education are continuously discussed among policymakers, scholars, and practitioners in tertiary education settings [23,58,59]. Almost all higher education institutions state that their mission is educating students to become good, responsible citizens in our society [22,26,60–62]. That is, their ultimate goal is to prepare students for an active civic life. Thus, this study mainly examined the CSE globally, as a part of civic engagement activities, to explore how postsecondary education attainment affects participation in CSE. From the findings of the current study, educational degree attainment significantly influences the individual to engage in community service in most OECD countries, considering other factors associated with CSE. The study also revealed that postsecondary educational attainment plays an especially important role in increasing

CSE among individuals. In addition, attaining postsecondary education is associated with an increase in CSE as a part of civic engagement and citizenship, which goes beyond the individual level and impacts the whole country.

It is important to acknowledge the limitations of our work. The outcome variable was measured using a Likert scale, but the intervals on the scale would not carry the assumption that the differences between points on the scale are all the same. Likert and Likert-type responses are popular psychometric items, and debates on whether the analysis using the Likert scale should be estimated using parametric statistics or non-parametric statistics are ongoing. However, according to Carifio and Perla [63,64], Likert responses are approximate ratio data. Additionally, individual items on Likert scales are not independent and autonomous but instead are connected to each other to yield a single unified result, which provide more reliable and fundamental construct than any individual item. Moreover, we performed the ordered logistic regression, non-parametric function as well; however, the results show considerably similar findings, which included statistically significant factors on CSE, compared to the findings of this study. Therefore, for an intuitive interpretation, we assumed CSE Likert-scale is a continuous variable. In addition to that, there are other possible factors associated with CSE, and those factors, such as information on community environment, and where they live and belong, would be included in our analytical model. However, due to the characteristics of the secondary data, we could not use these variables in our analysis and made our best attempt to analyze the given data. We hope that other researchers will further expand the analysis using more inclusive variables, and test our model using different sources, and ultimately improve upon our study.

Despite the limitations, this empirical study's global perspective could have important implications for policy and research. First, this study comprehensively analyzed how a variety of influential factors, including personal and family characteristics (e.g., economic, social, and cultural capital), educational factors, and national factors influence CSE. Furthermore, it reveals whether each of these variables has a positive or negative influence on CSE. Accordingly, the results of this study can contribute to an appreciation of the real challenges surrounding CSE and civic engagement issues, as well as the role of higher education. Other factors (e.g., parental education and working status) that influence CSE vary from country to country. Thus, policymakers and educators in each country must compare and evaluate the results and utilize them to improve their country's CSE. In addition, the methodology of this study was especially comprehensive and robust since it used the representative OECD national large-data samples and utilized a variety of exploratory variables and advanced analytic method, including diverse contexts at the individual and country levels. Additionally, it employed HLM, which had been rarely used to analyze this topic. Therefore, this study will assist researchers and national leaders in ensuring that CSE can be affected not only by individual-level components but also by those on a country level.

The empirical evidence of the positive association between postsecondary educational attainment and CSE, closing the previous research gap, and simultaneously adding to the previous studies (e.g., [51]). However, there is a dearth of past empirical literature related to those issues in each country, and thus limited data are available on this subject. Further studies are needed to investigate relevant factors, such as the relationship between the postsecondary education system and government (governance) in each country at the national level. This in turn influences improvements in community service and, more broadly, civic engagement. Moreover, based on the findings of this study, average national higher education attainment in a country is revealed as a significant factor influencing the average CSE of the country, which also verified as the purpose of higher education such factors as public service to society and commitment to civic affairs. Educational attainment has been one of the consistent predictors from previous studies. However, our study newly confirmed the importance of higher education attainment specifically as a motivator toward CSE at the national level. Future studies could also attempt to consider historical and political context in the country to examine how the relationship

between postsecondary education and CSE would be changed depending on those national contexts. Furthermore, studies could potentially trace how civic engagement and CSE are influenced by the deliberate development level of postsecondary education. Those trials could contribute to an appreciation of the real challenges surrounding CSE and civic engagement and the role of general education and tertiary education systems around the world.

In order to be effective in the college and university setting, service-learning opportunities for students should not only advance their academic learning, but also promote their civic engagement and responsibility. Scholars have suggested several important components of this process: mutuality, personalization, inquiry, reflection, community, citizenship, and democracy [65,66]. The activities should be mutually beneficial for both actors and recipients, and students need to personalize the service by cultivating meaningful interactions with others. Pedagogically, students must have enough time to reflect on and interrogate their experiences, think through any issues, and find ways to solve them. The activities should be also directly or indirectly valuable to their community. Through these experiences, students will be able to develop their lifelong citizenship in a democratic society.

Higher education institutions should also play an important role in reducing disparity in civic engagement accessibility among students with different socioeconomic backgrounds by providing more opportunities and resources for students who do have less accessibility [22]. For example, student affairs departments and professionals at colleges and universities provide a variety of co-curricular or extra-curricular engagement bonding opportunities (e.g., experiential learning) both on and off campus together with community engagement activities. This approach ultimately should be "a transformation toward justice and the greater public good" [67] (p. 86). In addition, in the midst of the COVID-19 pandemic, due to the development of technologies, online community service engagement has been introduced [11]; thus, higher education practitioners try to spread knowledge about out this new medium to students or adults who have lower accessibility and knowledge of community and civic engagement activities.

Consequently, this study hopes to offer new insights and ideas as to how CSE can be examined in postsecondary education settings across the globe and lead to a fuller understanding of the factors that contribute to CSE from diverse contexts, including both individual and country levels in 18 OECD countries. Moreover, policy makers and practitioners can obtain additional insights into what factors function as a commonality of improving CSE and what factors do not. Simultaneously, investment in postsecondary education can play a pivotal role at both the individual and country level in bolstering CSE. This study, therefore, will contribute to improving civic engagement in educational contexts, especially in that of higher education, thereby promoting the value of democracy and social mobility to produce a better world.

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Article

Cyber-Archaeometry: Novel Research and Learning Subject Overview

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Abstract: The cyber archaeometry concerns a new virtual ontology in the environment of cultural heritage and archaeology. The present study concerns a first pivot endeavor of a virtual polarized light microscopy (VPLM) for archaeometric learning, made from digital tools, tackling the theory of mineral identification in archaeological materials, an important aspect in characterization, provenance, and ancient technology. This endeavor introduces the range of IT computational methods and instrumentation techniques available to the study of cultural heritage and archaeology of apprentices, educators, and specialists. Use is made of virtual and immersive reality, 3D, virtual environment, massively multiplayer online processes, and gamification. The VPLM simulation is made with the use of Avatar in the time-space frame of the laboratory with navigation, exploration, control the learning outcomes in connection to the archaeometric multisystem work. The students evidently learned to operate the VPLM following operations made via visual and home-made scripting, gaining experience in synergy, teamwork, and understanding. The resulting meaningful effects of the cyber-archaeometry with virtual operations and virtual hands, texts, and video equip students especially for e-learning with the required basic knowledge of mineralogical examination, which help to understand and evaluate mineral identification from material culture and provides readiness and capacity, which may be refined in a real polarized light microscopy (PLM) environment.

Keywords: educational; virtual environment; virtual reality; gamification; 3D modeling; cultural heritage; cyber-archaeology; microscope

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1. Introduction

The higher education institutions are progressively looking for new ways to upgrade and update the quality of education, initiate student commitment, and manage knowledge resources. The high-tech development has a major impact on education, and technology-mediated learning is constantly advancing with the introduction of blended learning in educational institutions. Along this rationale, the introduction of novel educational science learning approaches is most welcome. The current state of the art in cultural heritage and new technologies learning in university syllabuses is undermined and new learning management approaches that combine blended programs (in a classroom and from distance) benefits the self-efficacy of students [1]. The various tools used to study material culture and interpret the data and the results derive from the disciplines of information technology, geodesy, GIS, 3D, and virtual reality [2–5].

We are aware that the ability to transmit knowledge and interpretation depends on the complexity of various factors: technology, format, precision, deduction–induction,

communication, context, ontology, etc. The archaeological information virtual ontology, or archaeological cybernetics, a further step forward shown here, refers to all the interconnective relationships generated by the datum, the transmission code, and its transmutability. The data are never neutral and, as a result, we must enhance the properties of the affordances [2,6–8].

A brief state of the art of the scientific literature of the novel subject and a comparison with works of a similar nature is unavoidably restricted by the basic foundations laid down by the tools used to record and handle big data taken from archaeological sites and grand excavation and digital imaging and documentation of unearthed finds with ultimate research, education, and pedagogical impact [6,7,9,10]. Earlier work on the present concept is only related to the initial presentation some five years ago [2,8]. Introducing a novel field, it requires an antecedent evolvement of the development of the digital and cyber archaeology task (scientific goal), the formulation, description, and justification of pursuing this new educational tool.

The information technology (IT), artificial intelligence, and high-tech in image processing have developed rapidly in the last decades in many aspects of our life, needs, and pursuits, and the archaeology, cultural heritage, of past cultures and environments have gained a lot. New terminology entered the scientific vocabulary and new disciplines emerged and gradually became establishing assets, such as: virtual environment, VE; virtual reality, VR; massively multiplayer online world, MMOW; virtual worlds; augmented reality, AR; gamification; serious games; and cyber–archaeology [2,11–13]. Thus, from simple digital recordings to multiple storage, interaction, and management of huge data, a cyberspace of the past is emerging.

It is this holistic approach we favor that integrates the insights of traditional archaeology, archaeological science, and digital archaeology, also offering a critical appraisal of the interface between digital methods and archaeological theory. It is the IT revolution that influences archaeological interpretations of techno-social change.

The first and pioneering monograph edited by Forte [14] on virtual archaeology and computer graphic representation of the past introduced and popularized the term virtual archaeology for the first time. The virtual archaeology is mainly visual, static, with graphics and orientated to photorealism [15]. Recently, new approaches have been added using various interactive practices. The 3D modeling is a very useful practice for the identification, monitoring, conservation, restoration, and enhancement of archaeological objects. In this context, the 3D computer graphics can support archaeology and heritage policy, offering scholars a "sixth sense" for the understanding of the past, as it allows them almost to live it [16].

In the late 2000s, cyber-archaeology (CA) transitioned to archaeology as a discipline. In 1997, it was first applied to anthropology and communication studies, where the connection between computer-mediated communications and online behavior as cultural artifacts was explained; see [6,17–20]. Cyber-archaeology was recontextualized when its meaning was expanded to include cybernetics after a workshop at a Theoretical Archaeology Group (TAG) meeting at Stanford University in 2009. CA is the digital management of much partial information in the field [6,7,21]. It is not necessarily visual, but dynamic, interactive, complex, autopoietic (self-organized) [22], and not necessarily oriented to photorealism.

It is Lake's article [18] that epitomized the history of archaeological computer simulation, starting with early 1970s simulation models, and focusing on those developed over the past twenty to twenty-five years, with a prelude to execution of laboratory exercises via browser.

The past cannot be remade but could be simulated, and CA is the process of simulation and reconstruction of archaeological finds or cultural materials. The archeology of the third millennium is able to process, interpret, and transmit much more data and information relative to the last two centuries. Cyber-archaeology provides new energy and excitement into grand narratives of technological revolution and culture change, yet it does further challenge the high-level theoretical explanations. The digital recording methods have

the potential to create large, regional-scale databases to ease investigation of high-level theoretical issues. In short, this field, emerging in the 2000s, has shown the potential of the IT revolution, which cuts beyond triteness and instead critically engages both its possibilities and constraints.

Most virtual archaeology research projects were visual-oriented in the 1990s; we now believe they will be cyber-oriented in the third millennium. The discussion of the phenomenology of cyber-archaeologies from virtual archaeology and related applications at epistemological, technological, and methodological levels through some significant theoretical approaches and case studies has been introduced by Forte [14] and later reviewed as cyber-archaeology [6]. Recently, Champion [23] argues that gaming in archaeological excavations are systems, experiences, or arguments.

Though this attempt is incomplete and very preliminary, the defiance is to draw up a cultural proclamation for the foundation of this work from different perspectives and with a variety of multidisciplinary contributions and theoretical discussions.

However, the development and applications to design cyber-archaeology's field of research coupled with archaeometry is being reconfirmed and really is proved valuable (in scholarly resources), and indeed, this post-modern revolution is more cyber than virtual, more sustainable than serving only academic interest [5,7,24,25]. Thus, in the field of archaeology and laboratories, the swiftly and progressive use of 3D digital technologies can design diverse and unexplored workflows in the spawning, portrayal, and communication of data [9,26]. This is making virtual labs practical and convenient and intelligent for e-learning purposes.

In such diverse discipline domains in cultural heritage, this cybernated migration of data and models creates unexpected results and more advanced knowledge, and Bateson thoughtfully (1972) forwards this process as the map-code of the cybernetic cycle. The learning of the code contains big data obtained in the field or processed in the lab, which are mandatory to handle by algorithms, interactors, and large storage machines, which after all generate a triggered feedback in lieu of predetermined inter-connections [6].

The simulation, that is, the enactive-dynamic behavior of the virtual actor and the digital ecosystem, is the focus of the cyber-archaeological process. As a result, different affordances and cybernetic models can be generated by the workflow capable of moving and migrating data from the fieldwork to a simulation environment: each can generate feedback and this is a new map code for the interpretation. The core of the process is not the model, data, or environment, but the interaction, the embodiment and the enacting that is the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. This is achieved and generated by mutual relations, i.e., it is addressed by cognition [6,22].

Along this amazing new information that offers novel investigatory tools to study the past, we have initiated the cyber-archaeometry project.

The IT and cybernated cultural heritage may be expanded to the archaeometry, also called archaeological science, an interdisciplinary field that emerged at Oxford in the 1960s [27]. Essentially, we make use of the CA methodology to a new concept in teaching higher education apprentices via a virtual environment for the investigation of cultural heritage and archaeological materials with natural sciences [28]. Archaeometry involves applications with the use of available instrumentation and methods to unearthed material culture of archaeological excavations, or basic research implying novel mechanisms for getting, e.g., the age or construction of equipment for solving a particular archaeological question.

It can be divided into seven categories with subdisciplines: (i) dating methods, i.e., physical and chemical dating methods, which provide archaeologists with absolute and relative chronologies, (ii) characterization and provenance methods, i.e., artifact analysis, mathematical methods for data treatment (including computer-based methods), (iii) prospection techniques, i.e., archaeo-geophysical, aerial, and remote sensing methods for the location of buried antiquities, (iv) bio-archaeological techniques for the study of ancient DNA and diet, nutrition, health, and pathology of people, (v) environmental approaches,

which provide information on past landscapes, climates, flora, and fauna, (vi) conservation sciences, involving the study of decay processes and the development of new methods of conservation and restoration of ancient remains, and (vii) archaeoastronomy, which is the study of astronomical knowledge of ancient and prehistoric societies from orientated structures, devices, and literature sources [28].

Whichever these thematic divisions are, we stress and promote the concept of a perpetually accredited scientific holistic approach (PASHA), which provides current answers to questions arising from contemporary or future problematic issues and/or reassesses past results in the spirit of updating and reassessment. It is a kind of meta-archaeology, which involves philosophy, archaeology, and natural sciences.

Apart from applications, archaeometry also develops research into new methods and materials to improve errors, increase accuracy, and, thus, reliability. The important contribution of archaeometry to cultural heritage and archaeology remained, for most of the years of its development, known either to a few open-minded archaeologists or to a narrow group of academia [28].

Therefore, a modern approach to cultural education and archaeological sciences is affordable with the use of new technologies: from virtual archaeology in cyber-archaeology and to cyber-archaeometry.

The technological tools derived from the field of natural sciences used to investigate past cultures and archaeometry and the reconstruction of past cultures, achieved from analysis of material culture as well as ideas projected onto material culture, could be approached via theoretical modeling and virtual labs.

The aim of present work concerns a first contact with cyber-archaeometry, which has started with the simulation of a petrographic (optical) microscope with the use of avatar in the time-space frame of the laboratory. The use of virtual reality-gaming software was to enhance the effective education of students in the problem-solving exercises of the archaeometry laboratory, without necessarily their presence in the laboratory. The used digital tools follow the theory of mineral identification in archaeological materials (here granite from Osirion in Egypt). The 3D virtual lab, educational aims, anticipated results, benefits in training on a virtual environment, and learning outcomes will be discussed. The work concept was initiated having in mind the rapid development of e-learning and distance learning processes in higher education establishments, and the need for securing (virtual) hands-on experience of university students to expensive devices for archaeometric work in the field and the laboratory. The benefit of learning is enhanced from prohibited access to student classrooms due to disasters such as the current pandemic and includes accessibility to courses taught from distance [29]. The stakeholders are the apprentices, and the present novelty offers potential to support the managerial and policy decisions. Through properly developed tools to navigation, exploration, and control, one achieves the goal. This goal is made via virtual and immersive reality, 3D, virtual environment, virtual processes, gamification with serious games, and the use of avatars in the time-space frame of the laboratory. The integrated plan triggers show up and develop certain theoretical, cognitive, methodological, empirical, or practical (implemental) goals, which are critically discussed.

2. Overview

A brief review of the scientific literature and a comparison with works of a similar nature, as up to date as possible, is necessary, so that the theoretical new contributions of this research are detailed. However, as can be seen during the development of the present field from the digital and virtual applications, the sources used are pumping ideas from IT, engineering, and mathematics. Reportedly, the novel field of cyber-archaeometry is the simulation design principles that help students' learning and interactions with digital applications in archaeology and cultural heritage, with the experimentation tools in various learning environments. In this aspect, it recalls the integration of science, technology, engineering, mathematics, STEM, with arts and culture (STEMAC); involving computa-

tional thinking, engineering education epistemology, computational science education in education, and more generally in learning and teaching approaches and learning objectives [30–34]. The new transdisciplinary and interdisciplinary field that emerges of cultural heritage and archaeology in pedagogics is much valued, in particular in the contemporary emergence from lockdown due to the pandemic, but reappraisal of working conditions too.

The use of the prefix "cyber-" derives from cybernetics, a term that has been given several definitions from the early days of the 20th century [35,36], as a scientific field in retrospect (science of cybernetics and the cybernetics of science) [37] and in other disciplines [38,39]. The word "cybernetics" comes from the Greek word κυβερνητική (kyvernitikí, "government"), i.e., all that is pertinent to κυβερνώ (kyvernó), the latter meaning to "steer," "navigate," or "govern". Cybernetics has evolved in ways that distinguish first-order cybernetics (about observed systems) from second-order cybernetics (about observing systems), such as in the diffusion of water to obsidian hydration dating [40].

The use of cybernetics in the present work:

(1) refers to an interdisciplinary and transdisciplinary field of science and humanities;
(2) incorporates and accommodates every natural or biological dynamical system; and
(3) it develops and interprets phenomena occurring on the space-time 3D set.

Use of cybernetics tools in online learning courses is developing to a sophisticated simulation process [41].

Accepted educational organization models are rapidly challenged by learning technologies. Developments since the 1970s have been reviewed, identifying how the three strands of (a) learning content development, (b) computer-mediated communication, and (c) learning management have been integrated into learning management systems (LMS) made possible by the World Wide Web.

It has been argued that mainstream LMS offer restricted pedagogic opportunities if they are adapted to existing organizational forms, instead of using alternative, easier, and more experienced organizational minimizing constraints. However, prophetically, Beer's work provides us with tools for the redesign of educational systems to make the most benefit from new technologies, guided by Illich's [42] critique of formal education.

Online learning includes offerings that run the gamut from conventional didactic lectures or textbook-like information delivered over the Web to Internet-based collaborative role-playing in social simulations and highly interactive multiplayer strategy games [43].

Furthermore, massive open online courses (MOOCs) provide new opportunities to a massive number of learners to attend free online courses from anywhere all over the world. MOOCs have features that make it an effective technology-enhanced learning model in higher education and beyond [44]. There are a lot of online learning platforms, such us Codecademy, Coursera, Edx, Udemy, etc. E-learning platforms are a fast-growing industry, especially after the advent of Covid-19.

Creating virtual environments offers new ways of educating students. Students could interact extensively with educational and laboratory material, even from their own space. The interaction is very beneficial compared to instructions based on texts or even videos that are not interactive. Virtual environments usually use 3D characters in a game environment, making the training exciting. Moreover, they support multimedia services, hence, students can watch videos, 3D animations, read text instructions, listen to audio instructions, and interact with 3D objects on stage. Those environments can be completely immersive, with 3D interactive functions that simulate, as accurately as possible, a real environment. Metadata is essential for virtual heritage to establish itself as a long-term research area, but metadata has to help the objectives of virtual heritage, which are arguably as much, or more, about education as they are about preservation [16,45].

Virtual training can enable many students to acquire knowledge and skills. On the other hand, virtual labs have been applied mainly in sciences such as physics, biology, chemistry, and in technological sciences.

In an earlier study about the reasons for creating virtual labs, the authors worked on the assumption that a significant portion of students go through labs with little thought

about what they need to learn, and just follow closely the written instructions for the experiment to get the expected results. The authors also showed that a primary factor behind this trend is the rigidity imposed by training labs with strict time constraints, large numbers of students, the cost of materials, and security issues. Most of the evidence supporting the value of virtual workshops comes from student feedback. Moreover, the authors of that study found that 75% of students said the software gave them the freedom to explore, focus on the basics of science, repeat procedures, and was easy to use [46].

Several virtual microscope creation efforts have been made but for other purposes.

From a search regarding virtual microscopes, we found several applications and approaches that do not meet the needs of an archaeometry laboratory but mainly applications of biology. Virtual microscopes were introduced into the teaching of histology and pathology at the University of Iowa (USA) in 2000 [47] and at the University of Leeds (UK) in 2005. However, the virtual microscope should not be compared with an electronic simulation of a microscope, which is obviously a complete operating model of a microscope.

At the University of Illinois at Urbana-Champaign in America—this work was funded by NASA in 2003 to provide simulated instrumentation for students and researchers from around the world, as part of a virtual laboratory. The simulation was made for an optical microscope that cost $ 500000, with the aim that every scientist and student can use such a microscope for free. However, NASA has stopped financing it several years later and automatically stopped the development of software [48].

At the University of Delaware, flash technology video and simple operation optical microscope display of the instrument was performed, with no interaction [49].

At South Dakota State University (SDSU) and at New Mexico State University (NMSU), something similar was produced with a little effort to show the use of the microscope as a game [50].

At the Australian Centre for Microscopy and Microanalysis by University of Sydney, a Virtual Transmission Electron Microscopy (TEM) was done. It includes basic imaging with flash technology 2D [51].

The Open University (UK) also developed a virtual microscope (www.virtualmicroscope.org accessed on 3 February 2021). Students are not learning how to use the instrument, but they can enlarge and rotate photos of thin sections from several rocks [52].

Finally, at the Open University of Greece with OnLabs a software application was created, which implements a virtual world simulating the biology lab, not with an avatar; a similar concept to ours, along with the instruments and the rest of objects in it [53].

Regarding the national, regional, inter-regional, and international level, there have been some major efforts that have coined the later evolution of virtual 3D gaming pedagogical dimension. In Europe, the Digital Research Infrastructure for the Arts in Humanities (DARIAH)-funded project is a large-scale, long-term, pan-European endeavor aiming to enhance and support digitally enabled research across the arts and humanities. It does not include cyber-archaeology or cyber-archaeometry works, but remains in our opinion an inadequate level of simply a slow process digitalization of arts and humanities in general, archaeology and cultural heritage being a small part without expected establishment of "digital infrastructures" of the type and level presented in our present work. International appeal for synergy with DARIAH-EU has been endeavored by Schoch et al. [54], based upon work built on earlier interview-based and questionnaire survey research in the "Preparing DARIAH" and EHRI projects, and on synergies with projects such as eCloud, ARIADNE, and NeDiMAH.

In the US, California, San Diego, a web portal is the primary Internet vehicle for communicating with the public and researchers worldwide about At-Risk World Heritage and the Digital Humanities, a cyber-archaeology project awarded a $1.06 million, two-year UC President's Research Catalyst Award from the University of California (UC) Office of the President to a consortium of archaeologists and information technologists on four UC campuses: UC San Diego, UCLA, UC Berkeley, and UC Merced. Cyber-archaeology integrated projects have been made on a regional and local scale [5,55]. The next US mission

rests on the Qualcomm Institute (QI) at UC San Diego, which develops technological and institutional innovations including ancient cultures and cyber infrastructure applications from Mayas to Near and Middle East [56].

Visual Studies are established also at Duke University and the DIG@Lab, with the main research topics being digital archaeology, cyber-archaeology, classical archaeology (Etruscan and Roman Archaeology), and neuro-archaeology, and case studies in Europe, Asia, South America, Middle East, and the US [21].

Despite the large number of publications describing projects based on game engines, there are relatively few describing how game engines can be used as interactive frameworks for collaboration, teaching, and videoconferencing. Thus, a cylindrical stereo screen of the HIVE, Curtin University, Perth, Australia, has been developed for such a purpose [57]. It addresses issues that contribute to a serious challenge for virtual heritage: that there are few successful, accessible, and durable examples of computer game technology and genres applied to heritage. Moreover, it argues that the true potential of computers for heritage has not been fully leveraged and they provide a case study of a game engine technology not used explicitly as a game but as a serious pedagogical tool for 3D digital heritage environments. They combine immersive 3D models and video conferencing, particularly for large scaled cylindrical displays, such as the curved stereo display (e.g., the avatar mirrors that track gestures of the speaker and triggers slides by pointing at the relevant objects; another option is to simply have a hand that points to objects in the scene—the virtual hand moves and points according to the tracked hand of the speaker).

All these major enterprises provide an accurate, precise, workable, simulated, and learning environment of ancient sites, archaeological environments, and 3D artifacts, which contribute decisively to the integrated and holistic study of past cultures, making the field work and museum objects accessible to society and hitherto offer a superior pedagogical potential.

3. Instrumentation

Figure 1 shows the simulation of a petrographic (optical) microscope with the use of an avatar in the time-space frame of the laboratory, that navigates, explores, and controls the learning outcomes in connection to the archaeometric multisystem work.

Figure 1. Polarized light microscopy (PLM) with various components (© lab of archaeometry, University of the Aegean, Rhodes).

Use is made of virtual and immersive reality, 3D avatar, virtual environment, massively multiplayer online processes (MMOP) (virtual processes), and gamification with serious games. A demo is presented online [58]. The benefits include advantages con-

cerning repeats as trial and error at any time, overcoming costly demands of purchasing electronic equipment.

Virtual Development and Materials

Here, we create a different software, which is based on 3D serious games, using immersive technology with a high degree of presence for the students. The use of avatars, 3D graphics, and gamification aims to ensure success not only in learning the microscope but also in detecting the minerals through information, images, and short videos including evaluation exercises for both knowledge and skills.

This virtual microscope has been designed to train students in learning and using the polarizing microscope. They use virtual hands to operate the instrument guided by speech and texts by human avatars, a laboratory assistant, and a geoarchaeologist (Figure 2A) and snap shots of the material culture from the Osirion Temple at Abydos, Egypt, along with the preparation of the thin section on a glass, the setting of the thin section onto a physical PLM table and images before focus, adjustment, and the clear image with the minerals (Figure 2B).

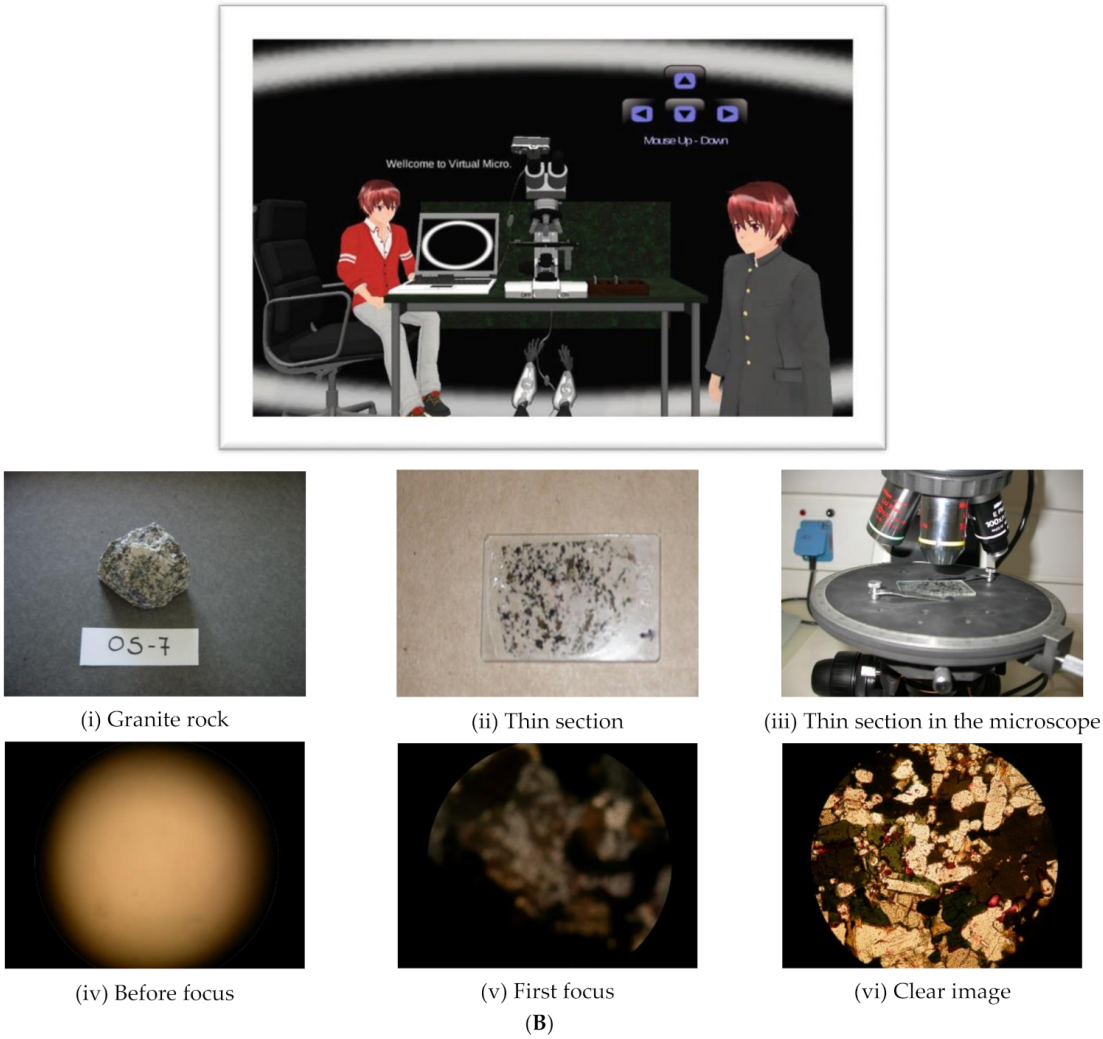

Figure 2. (**A**) Virtual microscope laboratory; the instructor, the apprentice, the VPLA and the operating hands. (© Authors 2021); (**B**) (i) A piece of granite from the Osirion Temple at Abydos, Egypt, (ii) the derived thin section on a glass, (iii) the setting of the thin section onto a PLM table, (iv) before focus, (v) adjusting the blurriness with rotating lenses, and (vi) the clear image with the ingredient minerals (© Lab of Archaeometry, Rhodes, Sample No OS-7/RHO-139).

It is very useful for students to learn the material culture composition and technology of stone implements from the archaeological excavations. It is imperative for the knowledge of knowing the recipes for making ceramics, the composition of rocks, and using databases to identify the types of manufactured artifacts and quarries used to produce implements or monuments. They become also acquainted with the ingredients of ceramics, become familiar with the minerals (main component of rocks), and acquire information on archaeo-materials.

The use of a polarizing microscope in the archaeometry laboratory concerns the enlargement and analysis of small samples, showing the structure of small fossils and the texture of rocks. The observation and analysis of the samples is done by examining a thin section, a few micrometers thick. Initially, a piece of material of about 1 mm and an area of 2 square centimeters is detached. This slice is then smoothed to the point where a flat surface is created like a mirror. The sanded surface is pasted on a glass surface and the sanding continues until a thickness of about 30 micrometers. A light beam of polarized light passes through the petrographic microscope to this thin section.

An example of analysis comes from the Abydos, the greatest of all cemeteries and the home of god Osiris. The adjoining building is the Osirion, which features a central "Island of Osiris" made of granitic stone and surrounded by an artificial canal and sandstone wall, all of which were deep underground in Pharaonic antiquity, invisible to the eye and unknown to all but the priests. A sample of the granitic assembly pillar was examined and was dated by Optical Stimulated luminescence (OSL) to 1980 $\pm$ 160 [59] in accord with the archaeological age Middle Kingdom, 11th to 14th dynasties, 2134–1690 BC. Mineralogical qualitative examination revealed: Quartz: moderate, Albite: moderate, Orthoclase/Microcline: low, Biotite: low, and Actinolite: sparse quantities [60].

Figure 3 shows the thin section microphotograph of the studied granite, and Figure 4 is the place of origin, the Osirion Island in Egypt, surrounded by sandstone walls and the granitic pillars.

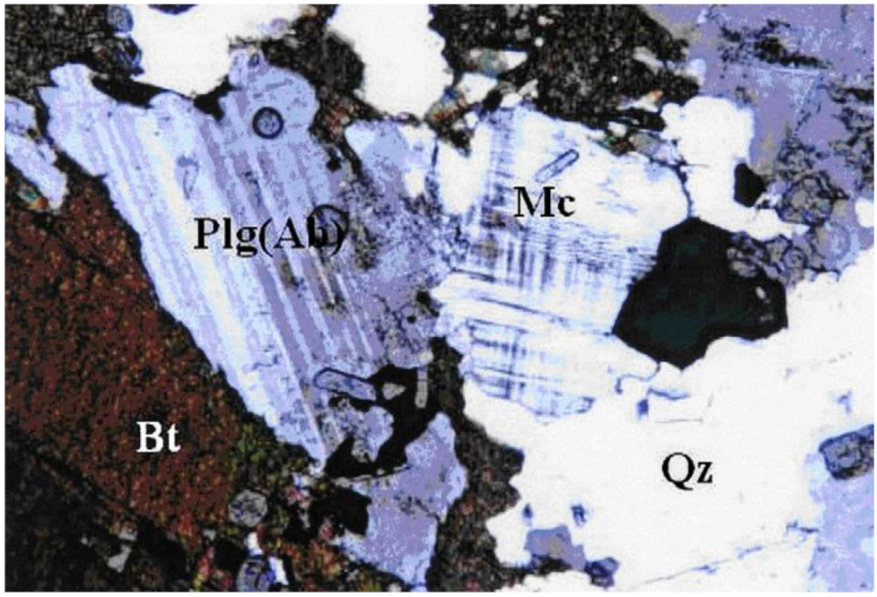

Figure 3. Thin section microphotograph of granite OS7 (crossed polars, magnification x60). Qz, quartz, Plg (Ab), plagioclase feldspars (Albite); Mc, microcline; Bt, biotite.(© I. Liritzis).

Figure 4. (**Left**) Top view of Osirion at Abydos with the granitic pillars and the inner part flooded with water. (**Right**) I. Liritzis (left) and Prof. El Gohary (right). Sampling comes from the pillars (© I. Liritzis).

For the creation of the virtual class, the priority was the 3D model of the microscope (Figure 5a), which was given for free by the creator Olek Pieta. Two movements were added to the model of the microscope with the 3D Unity game machine (raising and lowering the bank for focusing and rotating the objective lenses for magnification). From the free libraries of 3D models on the Internet, furniture, and objects (Figure 5b) as well as 3D humans (Figure 5c) were added to the space of the laboratory. Basic 3D movements (walking, sitting, hand movements, speech movements) were added to the 3D humans to make their presence in the laboratory as real as possible. A 3D hand model (Figure 5d) was also placed so that the student could operate the microscope.

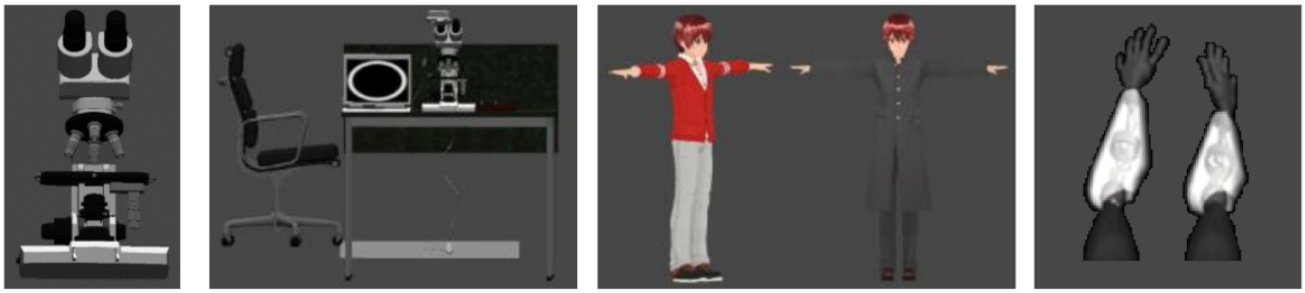

Figure 5. 3D models of microscope (**a**), furniture (**b**), humans (**c**), and hands (**d**) (© Authors).

The development of the application made by the 3D Models and Game Engine Unity3D. Visual scripting PlayMaker was used for most of the triggering scenarios between user and visual microscope. PlayMaker is a plugin for 3D Unity offering an intuitive structure with States, Actions, and Events to quickly build behaviors (Figure 6).

The students learn to operate the VPLM following the next operations, which have been made via visual scripting and other home-made scripts: (1) turn on the instrument by pressing the ON switch, (2) place the thin section of the sample they want to observe, on the microscope bank, (3) the thin section is placed on the bank, they must rotate the focus screws, (4) cautious rotation of the macro screw until they see the sample clearly and then they focus with the micrometer screw to see it as clearly as possible.

Texts and recorded texts from digital speakers were used to communicate with the students. For the educational material of mineral identification, a same virtual class was used with two boards in which the necessary texts, photos, and videos were presented. The navigation in the educational material can be done with the 3D hands of the virtual microscope but also with keyboard keys.

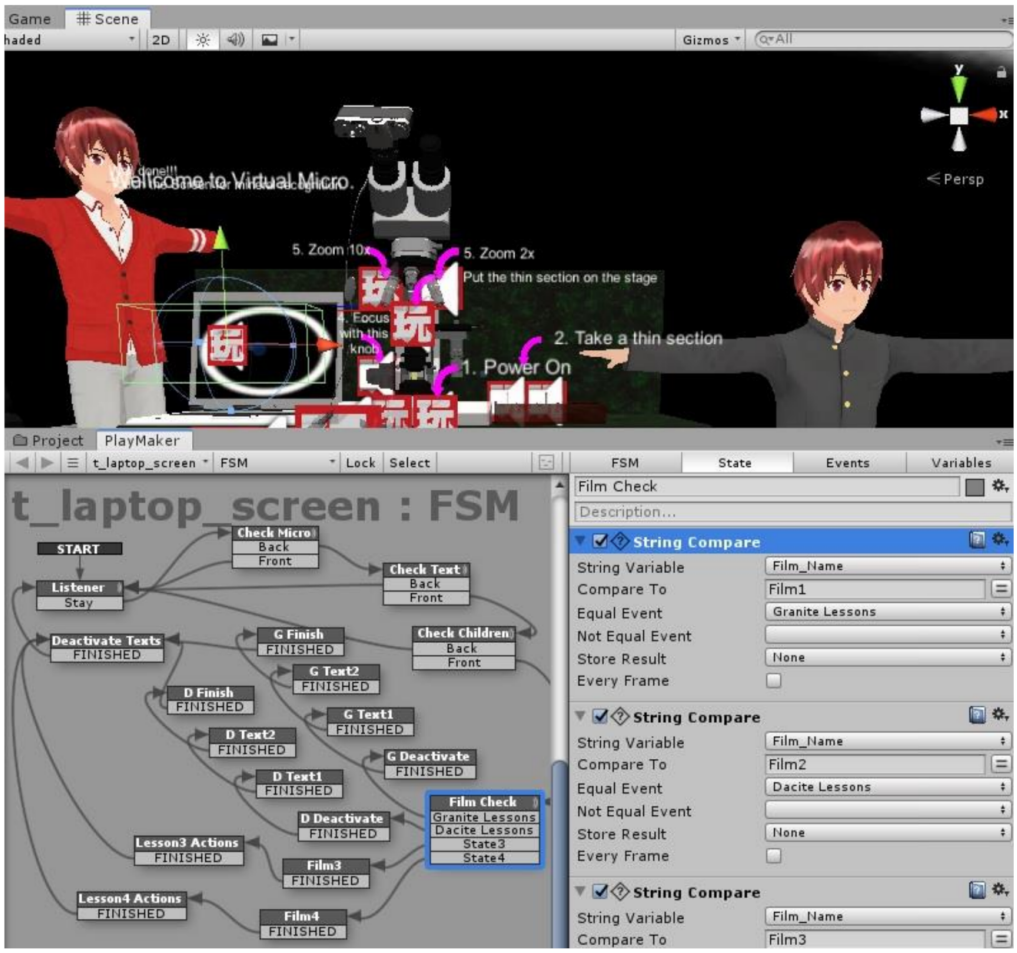

Figure 6. An example of programming inside 3D Unity with PlayMaker, which for every step the student controls his hands in space (passing through invisible trigger points) and activates respective algorithm and directs the apprentice to get the right answer (© Authors).

A logic diagram used to identify the minerals contained in granite rock (Figure 7). Students observing the properties of minerals through photos and video clips and by following the logical diagram are trained to recognize granite minerals.

The identification of minerals follows a gradual process and is examined visually by distinguishing the minerals according to properties that can be distinguished from the passage of polarized light such as color, relief, cleavage, and pleochroism by rotating the microscope bank.

The logic diagram for the identification of minerals in a granite thin section was coded with Playmaker and integrated into the software using the necessary images, adding text with explanations, and allowing the student to explore the next characteristic of the diagram with the (left) or (right) selection button of the teaching material board, pressing with keyboard keys or student 3D hands.

The first characteristic that is observed is the *color*. The colorless minerals (left) are usually quartz and feldspar and the colored minerals (right) biotite or hornblende.

The second characteristic that is observed is the *relief*. The relief of a mineral is how it appears to stand out in relation to the medium that surrounds it. The difference in refractive index between tangential crystals gives the impression that some of them are elevated relative to others. This also makes the boundaries of some minerals appear sharper.

For the colored minerals on the thin section of granite rock, the ones that have a low relief are usually biotite, chlorite (left) and those with moderate relief hornblende (right) (Figure 8).

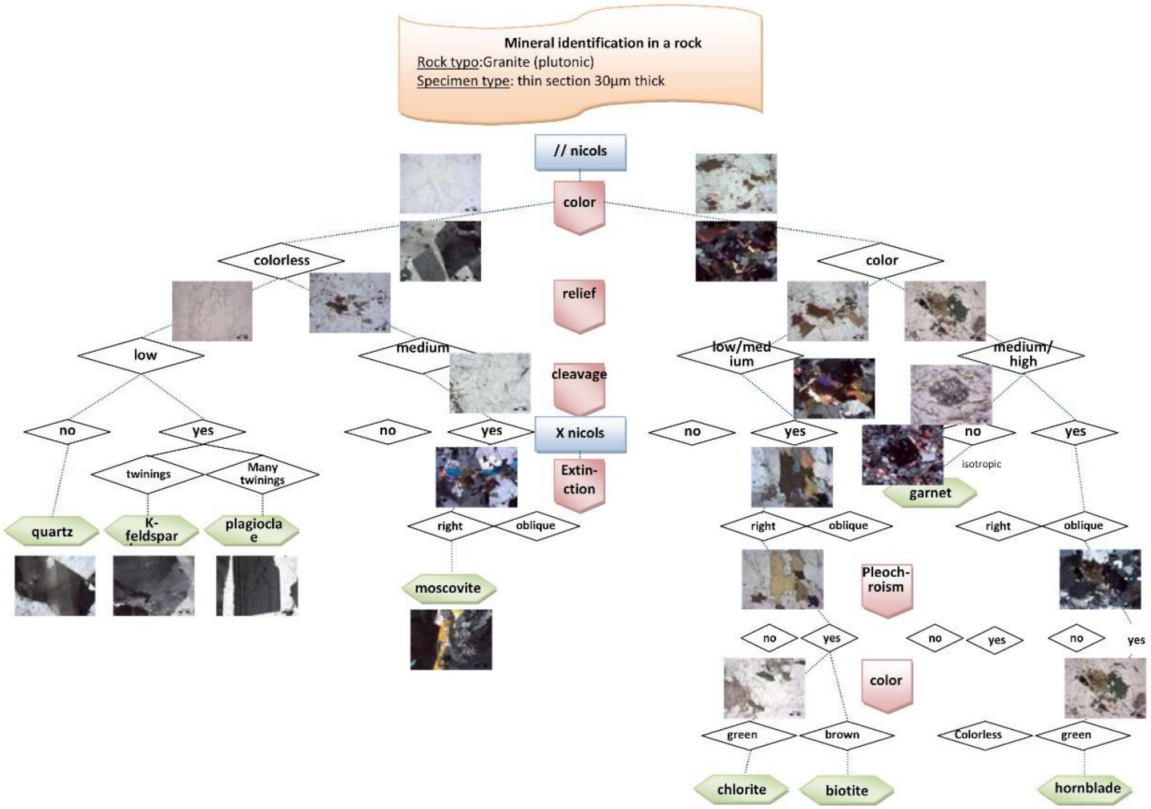

Figure 7. Steps to identify minerals in thin sections of rocks (pers. Comm. Prof. I. Iliopoulos, University of Patras).

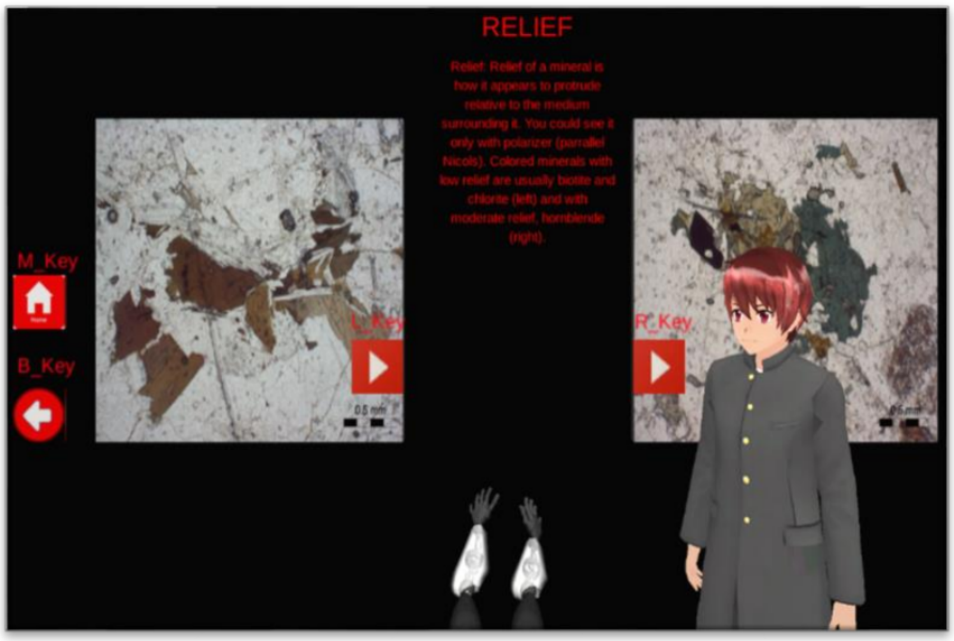

Figure 8. A photo capture of the virtual class (© Authors).

The third feature is *cleavage*. It is the property of a mineral to break or tear at certain levels, at which the atomic structure of the mineral is weak. For the thin section of granite in colorless minerals, if cleavage is not observed, no mineral is recognized. If cleavage is noted, then it is probably muscovite. No presence of cleavage also means no identification

for the colored granite minerals. With cleavage we can identify biotite and chlorite (left) and hornblende (right) in conjunction with the next observation feature, pleochroism.

The colored minerals change the intensity of their color by rotating the bank of the microscope. This property (*pleochroism*) is important as it can be used to distinguish between minerals, which are difficult to distinguish macroscopically. Pleochroism occurs only in colored minerals and is observed only with a polarizer. For chlorite and biotite, it is observed that they change color from light brown to dark brown. To make this change visible, two video clips are included in the virtual microscope. Two video clips also presenting the color changing of the hornblende, where color ranges from yellow-green to brown-green.

During the mineralogical examination, the main diagnostic features for the identification of minerals are the crystalline form (color and relief), cleavage, and other optical properties as the polarized light pass through them [47].

These virtual operations with the virtual hands, texts, and video equip students with the required basic knowledge of mineralogical examination, which has a twofold value: (a) to understand and evaluate mineral identification from material culture, and (b) readiness and capacity that may be refined in a real PLM environment. Moreover, apprentices acquire a large experience on the content of archaeo-materials, learn to function the device and associated physical-chemical mechanism, become familiar and gain experience in an abundance of free chosen time.

4. Discussion

The construction of the virtual PLM (VPLM) forms the foundation for further development of virtual archaeometric equipment for learning the methods and extract the relevant information. It establishes a new convenient and low-cost application bound to make future archaeological analysis faster and more precise. Moreover, through remote connection, scholars from all over the world can participate in the identification and identification of antiquities. Because the operation can be repeated, this application gives all students the opportunity to operate. Analyzing various results from different angles and viewpoints is no longer just a standardized operation and answer. The physical device cannot return to the previous action for observation at any time during operation. This application can repeat steps so that students can analyze the results in more detail in their studies. Last, if the physical device is used for a long time, there will be problems with inaccurate identification. This application can indeed reduce the cost of equipment replacement and measurement errors.

With this rationale, the cyber-archaeometry (CAm) is the digital IT process of simulation, restructuring, and management of archaeometric processes from the field of natural sciences in relation to material culture, investigated variously (dating, prospection, analysis, technology, provenance, archaeoastronomy, etc.), either as optimum recruited image or as targeted research quest [2]. If this cyber era is seen as a retrospective concept, one has to compare the two approaches in the development of digital archaeometry from archaeological procedural (processualism) in post-procedural thinking, in order to achieve the analysis of hybrid forms of both approaches, achieved by procedural tools (statistical analysis and quantitative methods in different fields, mathematics, geography, archaeometry, anthropology, archeology, and related disciplines). The above is an example of the emergence of cyber-archaeometry.

It is most needed in the present era with the pandemic where online lectures and especially learning involve (virtual) hands-on instrumentation for measuring material culture.

One of the first findings (of archaeological processualism) from the digital point of view was the use of statistical processing and quantitative methods in various fields, including mathematics, geography, archaeometry, anthropology, archaeology, and related disciplines. The critique of subjective methodologies illustrated the need for hyper-taxonomies to understand the past, and this archaeology of computing seemed a tangible and sustainable way for the dream of the process: an objective “scientific” expounding.

In the field of data interpretation, processing, and exchange the digital representations provide new perspectives and a modern approach to training and education, but also to science. It is important to those who understand virtual cultural dynamics through virtual labs [2,6,8]. The motto, "The past cannot be remade but could be simulated" may now be rephrased to "The archaeometric instrumentation and methodologies cannot be available but could be simulated".

There is no doubt that the novel e-learning technologies for cyber-archaeometry have great potential for learning and the organization of education. However, from our project and student interactive process, it is concluded that it is the design and application conceptualization that determines the impact of the present and more archaeometric methodologies, and it is evident that people have widely differing views about their proper use. To understand these, it is prudent to recall and reflect on an earlier investigation about the short history of learning technologies [41]. The introduction of the Internet, and the World Wide Web, appears to have made possible holistic learning for all three of these aspects—content delivery, communications, and learner management—to be integrated into a single system. Hence, the learning management systems (LMS) or the virtual learning environments (VLEs) began to emerge, contributing to online access to computer-based materials culture, providing communication tools, and allowing teachers to provide assessments, track students, build course materials, and manage the whole process.

Cyber-archaeometry started with the VPLM but will have a rapid development, in the near future, for other techniques and methods of the archaeological sciences enriching the curricula with similar virtual environments. Such a case is the obsidian hydration dating, which is one of the dating methods to determine the age of an obsidian (natural volcanic glass), which was a sharp blade for prehistoric people's daily needs. A hydration layer is formed inside the rock, with a width that varies depending on the time of water penetration, the temperature and humidity of the environment, and its special physic-ochemical structure. The longer the diffusion lasts, the older the obsidian object. The 3D representation of the process of hydration of obsidian is primarily educational, so that students understand the mechanism of hydration in different sources of obsidian and from different environments through a visual language. At the same time, however, the 3D presentation of dating with obsidian hydration will prove the network of codes of interpretation (mathematical algorithms, equations) and diffusion time. Through the simulation, the disordered but with predominant orientation of moving water molecules into the obsidian tool surface, the apprentice gets a sense of the diffused water rim, which is a function of the age of the tool since its last use [40] (Figure 9).

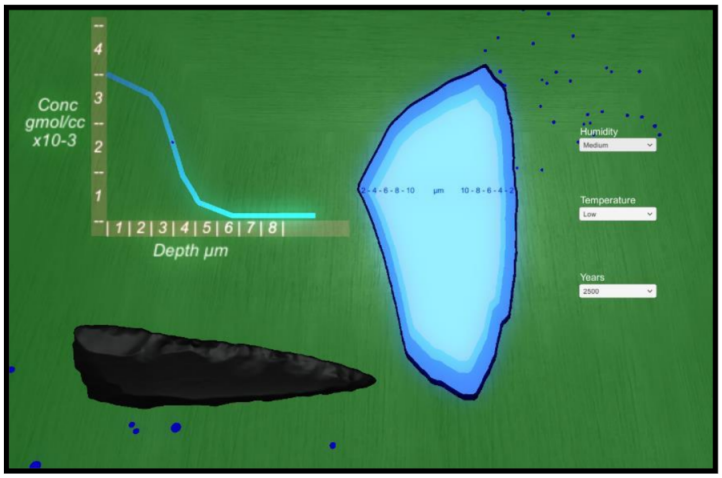

Figure 9. Screenshot from the obsidian diffusion software; the obsidian blade, the simulated diffusion rim in dark blue, and the X-Y plot of concentration of water molecules as a function of depth (work in progress, see our video simulation in [58]).

Undoubtedly, technology is providing tools that provide radical new opportunities for education, but simply adding technology to the existing mix is not enough. We need to use technology to develop better pedagogies, and most importantly, to redesign educational organization at all levels, from the course to the national system, to allow potential benefits to be realized [61,62]. The rapid changes in technology affects educational roles and learning outcomes, and cyber-archaeometry falls within this new era. Surely the completion of a reasonable spectrum of available archaeometric methods to a virtual merging environment needs the financial support of the Institution, but from a complexity management perspective, it is important to note that new education subjects, such as the cyber-archaeometry, require a new role in educational policy. Our thesis towards the importance of the individual, along with the pre-existing and continuously evolved theoretical frameworks, concerns the general (world, language group, etc.) and local policy and organization, without discrimination. At any rate, it is not necessary for the board to know or understand all issues, but to ensure that intelligence and operation function well and are a properly balanced [63] viable system model restated by Liber [41].

The latter is reinforced by the results that showed that students as adult learners should be involved in the design and improvement of software. This is in line with the theory of Mindtools, according to which educational software should function as a tool in the service of students, to develop critical thinking and to acquire a high level of knowledge and skills [64].

5. Pedagogical Assessment

The experiencing in the acquisition of knowledge is efficient with an enactive cognitivism, taking cognition as an action of inculcation in the teaching. In terms of the novelty of the virtual lab in the cyber-archaeometry discipline, the cognition is enhanced by the comprehensive triggering experience and these capacities belong and refer to cultural contexts.

Hence, the attainment of data from material culture concerning constituents, physical-chemical mechanisms for dating, characterization, provenance, locating buried antiquities, and more, could be identified in the mutual interaction between virtual action and experience and consequently between action and knowledge.

The present project searched the ability of a virtual archaeometry lab with digital characters and gameplay elements, to increase student participation and to see how the learning performance was affected using virtual lab exercises. Equally important were the research questions posed as part of our goal: Could students express their educational needs? Could they be involved in the design of educational applications? What are the students' opinions about the effectivity of such educational software in archeology?

The construction of the VPLM, the students' reactions during the working, and the interactive process and operational tasks have produced interesting results.

Briefly, the meaningful effects of the cyber-archaeometry with a 3D VPLM (in a similar manner for other methods and electronic devices from archaeometry) are summarized as follows:

The educational aims and anticipated results that were satisfied:

- Execution of laboratory exercises from internet via browser.
- Making a virtual lab for education of university students (e-learning or from distance) without physical presence.
- Learning the functioning of lab instruments for archaeometric work.
- Enable students to discover knowledge through these processes, but also to interpret in their own way the laboratory results.

The benefits in training and advantages of learning from the VPLM included:

- To perform at any time without help from assistants of the lab.
- Cost saving
- Avoiding disasters and loss of material.
- Repeat of an experimental exercise.

- Partial steps can be repeated, giving students the opportunity to analyze the process from different perspectives and opinions.

Concerning the learning outcomes, students:

- recognized content of thin sections (minerals, organic matter, fossils, scrap fragments, mineralogical structures etc);
- acquired a wide spectrum of the content of archaeo-materials;
- accepted trial and error;
- understood the functioning of equipment;
- were familiarized, and;
- gained experience in synergy, teamwork, and understanding.

The results have shown that the 3D laboratory space, the game elements, and the automated exercises, excited the students and increased their desire to participate in the educational activities. A positive result was the satisfactory acquisition of knowledge based on their evaluation results, in relation to the level of information they met. The level of difficulty is a matter for further research, as it can also be a deterrent to using the software.

The existing learning processes in classrooms and laboratories (where available, literally in exceptionally few cases) follow the traditional PowerPoint or oral teaching followed (in some cases) by homework and essays. However, in the archaeology and cultural heritage investigation one needs measuring equipment, basics in natural sciences. In the development of cybernated methodologies, the analysis results are a message for the higher education service policy and practitioners in the institutions of different types and levels, which along with potential users' characterization open a new era in educational sciences.

With these results, the research problem and research goals and pedagogical aims are fully identified and satisfied in this work [57]. The scientific level of the present pedagogical concept has certainly the potential for generalization in any geographical, cultural, and organizational area.

Overall, handling scientific instruments, data collection, data processing and analysis, observation of results, interpretation-explanation of observations, and presentation of results are skills that are very important for students to acquire during their laboratory practice [65].

However, the instruments used in the archaeometry laboratory have a high cost of purchase and maintenance when used by students in the context of laboratory exercises. In addition, the time that students can use the instruments is determined by the opening hours of the laboratory and is relatively limited, while the number of students who practice on the same instrument makes it difficult to use.

Lack of resources in universities is a constant problem that in many countries creates an inability to perform many experiments in archaeometry laboratories. With the use of virtual labs—as, here, the cyber-archaeometry project—the above restrictions may no longer prevent students and researchers from enhancing their skills and knowledge in the most effective learning outcome, the experiential participation.

6. Conclusions

The VPLM for cultural heritage in the digital era is made via virtual tools and the development of the application is made with 3D modeling and the Game Engine Unity3D as well as for the purpose designed algorithms. The 3D virtual polarized light microscope has been constructed in a virtual laboratory environment and enables the student to comprehend complex physical/archaeometrical terminology and instrumentation. Making use of free codes and written scripts, apprentices followed a methodological way to identify minerals in archaeological materials, learning their characteristic properties in relation to operational modes of the PLM. Apprentices are becoming familiar and tuned with the modern trend of learning (distant learning), and institutions and tutors complement costly equipment for archaeometric results with a built-up cyber-archaeometry project. Here, we initiated a first step for the cyber-archaeometry, while next constructions could include spectroscopic and dating methods, etc. The benefits emerging from the concept of

developing virtual archaeometric environments include recording and managing many diversified big data, applicable to a wide spectrum of archaeometric devices and methods, and provide strength, modernization, and alternative experiences in education making use of the high-tech and IT tools.

Amongst the meaningful effects and merits of the cyber-archaeometry with a 3D VPLM are: execution of laboratory work from the Internet via a browser, making a virtual archaeometric lab for education of university students (e-learning or distance), and learning the operation and methodology of archaeometric devices for measurement processes related to chronology, provenance, and technology strengthen effectively students' knowledge and triggers interest and curiosity for interpretation of laboratory results. We have documented the benefits in training and advantages of learning from the VPLM and satisfactory learning outcomes, with major issues being the gaining of experience through synergy, teamwork, and understanding.

The research implies a new educational tool, which can be expanded to other devices and methods without limitations in the way of acquisition of knowledge in the particular course of archaeological sciences. It provides clues for an integrated policy to the current and future learning processes taken by higher education institutions and policy makers.

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Article

Using Peer Review for Student Performance Enhancement: Experiences in a Multidisciplinary Higher Education Setting

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Abstract: Nowadays one of the main focuses of the Spanish University system is achieving the active learning paradigm in the context of its integration into the European Higher Education Area. This goal is being addressed by means of the application of novel teaching mechanisms. Among a wide variety of learning approaches, the present work focuses on peer review, understood as a collaborative learning technique where students assess other student's work and provide their own feedback. In this way, peer review has the overarching goal of improving the student learning during this process. Peer review has been successfully applied and analyzed in the literature. Indeed, many authors also recommend improving the design and implementation of self and peer review, which has been our main goal. This paper presents an empirical study based on the application of peer review assessment in different higher education BSc and MSc courses. In this way, six courses from different studies at the University of Malaga in Spain are subject to the application of peer review strategies to promote student learning and develop cross-wise skills such as critical thinking, autonomy and responsibility. Based on these experiences, a deep analysis of the results is performed, showing that a proper application of the peer review methodology provides reliable reviews (with close scores to the ones from the teacher) as well as an improvement in the students' performance.

Keywords: peer assessment; peer review; collaborative evaluation; higher education; rubric

1. Introduction

The integration of the Spanish university education system into the European Higher Education Area (EHEA) has entailed a paradigm shift in the teaching-learning process, leading towards a student-centred learning (SCL) approach where the learner and their needs are the primary focus. Under this perspective, active collaboration replaces passive knowledge transmission, with both teachers and students becoming mutual active contributors to the education process. Thus, successful mutual responsibility becomes critical in enabling the development of the learners' autonomy [1]. In Spain, this change in

the teaching-learning paradigm (or from the system of credits based on teaching hours to workload) has entailed a conceptual change in the higher education system [2,3].

The transition towards SCL has required the adoption of different or tailored forms of learning, resources and evaluation [4,5], so the transmission of technical knowledge and the methods of assessment and evaluation are aligned with competence development. Evaluation systems are one of the issues which have been most affected by the convergence towards SCL since they are one of the essential elements in the planning and execution of the teaching-learning process [6]. As indicated by Rodriguez-Esteban et al. [7], today evaluation is not understood only as a final act, being rather a process that is part of the same learning system. Not only must they serve to accredit learning, but they must also help students to learn and teachers to improve their teaching [8].

In this context and among a wide variety of learning approaches, *peer review* stands out as a key tool for SCL. Peer review, applied to the education field [9], is a collaborative learning technique where students assess other student's work and provide their own feedback with the overarching goals of improving the student learning process during this process, enhancing the understanding of the peer's work (maybe with a different approach) and improving the quality of the final product [10]. It is also referred to in the literature as peer evaluation, peer response, formative peer assessment or peer editing [11]. From now on we consider the term *peer review* in this article. This technique aims to involve students in the evaluation process, allowing a review of the material from a critical perspective, so that, when they analyze different approaches and points of view that may not have been considered when performing their task, students will have a more global vision of their learning in the course. During this collaborative process, the transfer of knowledge is mutual: in those who give the feedback and those who receive it, since this activity triggers critical reasoning and self-assessment in both sides [12]. Rubrics, as identified by Hafner et al. [13] are normally used. These provide a common scheme (usually prepared by the teacher in collaboration with the students) for assigning marks in each step of the assigned task, guiding students during this process.

1.1. Related Work

Peer review has proved to be a powerful evaluation strategy that brings a number of advantages over classical methodologies, such as facilitating the students' acquisition and development of skills and promoting their capacity of self-direction of their own learning [14]. Previous studies as Nicol et al. [15] have shown that, during the review process and the generated feedback, the evaluative judgment of the students is improved, both about their peers work and their own work. The analysis of other perspectives also greatly contributed to provide them with a deeper understanding of the course material [16]. A growing ability to give constructive feedback during peer review has also been shown in first-year students [17], who may be unaware of professional standards and expectations and reluctant for critiquing work and writing thoughtful feedback. Promoting independent learning, increasing student motivation, building problem-solving skills are also notably advantages to remark in this learning process [18].

Peer review has been widely applied and analyzed in the literature. In Saiz et al. [14], peer review at university is analyzed, highlighting the characteristics of this strategy and the conceptual, institutional and relational difficulties of its implementation. Challenges and benefits of the implementation of self and peer review and identifying potential inhibitors in practice are explored in Adachi et al. [19]. Moreover, authors also make recommendations about improving the design and implementation of self and peer review. Amendola and Miceli [12] propose a peer review methodology completely conducted through online technologies (in particular using the Moodle e-learning platform) showing the benefits such as lack of space and time in the standard lesson environment applying this methodology. In Indriasari et al. [20], a survey of peer review of source code in higher education showing how such activities have been implemented in practice, examining instructor motivations and the primary benefits and difficulties of this practice have been

reported. Authors also identify a wide variety of tools to facilitate the peer code review process. Peer review has been been widely adopted by major massive open online course (MOOC) platforms, but there is little evidence about if it is appropriate or under what conditions. In Meek et al. [21], student performance, participation and opinions of a peer review task of a science course in a MOOC are examined. According to Reddy et al. [22], the positive impact of training in peer review learning experiences on science students over three years in higher education is demonstrated. In Gaynor [23] the quality of peer feedback, the importance of assessments and student perceptions are investigated.

Apart from the aforementioned topics, there are other issues which have also been previously addressed by the peer review literature, such as the influence of cultural perspectives [24,25] or the analysis of students perceptions [26,27]. Moreover, Panadero et al. [28] investigated the impact of friendship on students scoring, finding a positive impact of using rubrics on scoring objectivity. However, the overscoring effect generally observed among students was amplified when the use of a rubric was accompanied by a high level of friendship between assessor and assesses. The influence of peer-related factors such as gender on peer-awarded marks is studied by Lagan et al. [29]. They observed the presence of a slight and positive gender effect between participants of the same gender over participants of different gender, with female evaluators being more consistent at awarding marks. Another branch of the peer review literature focuses on the assessment of the effectiveness and reliability of the use of this technique for educational purposes [30,31].

Within the Spanish context, the literature also provides some experiences in applying peer review to the higher education context. For example, one of the first documented experiences was conducted by Sánchez Rodríguez et al. [32] in an Education Science course at the University of Malaga. They found that although students' scores were slightly lower and more concentrated than those awarded by teachers, both were strongly correlated. Regarding students' perceptions about the vast majority of the respondents showed a positive attitude about the possibility of valuing and being valued by peers. Conde et al. [18] applied peer review to technological courses at the University of Leon to help students in technical studies to develop specific abilities such as critical thinking and get more involved. They evaluated student's opinions and performance and found that the application of peer review increased students participation and led to higher scores. Moreover, also by comparing students and teacher scores, they observed a significant and strongly correlated relationship. The quantitative data analysis about students' perception showed that, in general, the level of satisfaction regarding the methodology's appropriateness and its beneficial role in acquiring critical thinking is elevated. Only first-year students showed some concern regarding its use. Finally, it is also worth mentioning the study of Dopico [33] at the University of Oviedo, who found that emotional aspects related to personal criteria other than prearranged ones seemed to intervene in peer review processes. Besides, he also observed that the use of digital tools for the peer review exercise enhanced the motivation of the students.

1.2. Contributions of This Paper

Despite these clear advantages, there are very few courses at the University of Malaga (UMA) in Spain that apply strategies of self-assessment, coevaluation or peer review methodologies. The fact of identifying errors of peers or own mistakes during evaluation, provides a stable critical base to continue the construction of knowledge, while giving confidence to students on the skills acquired with a strengthening of them. In the literature [34,35] it is also mentioned some factors that limits the adoption of this technique such as: (1) not having the necessary maturity to evaluate, (2) not taking the evaluation seriously, (3) having negative attitudes towards an evaluation of these characteristics and (4) considering the evaluation as an additional load.

Although all these studies give a valuable insight into the use of peer review for evaluation and assessment in higher education settings, each of them performed the peer review for the evaluation of different types of assignments and in different scientific fields. Starting from these efforts, and by adding to the literature, the study described in this

article aims to gain more insight into the possibilities of formative peer review and its application in the classroom, setting the first steps towards continuing the much-needed research on the use and performance of peer-assessment methodology in the future. Thus, in order to assess the effectiveness and reliability of peer review, this study aimed to answer two key questions:

- Does the use of peer assessment improve students learning?
- Is peer review an effective and reliable method for evaluation?

By performing this peer review methodology we have also aimed at the development of certain transverse competences in students, such as responsibility and objectivity when making decisions. The study has been developed in six STEM (stands for science, technology, engineering and mathematics) courses at the University of Malaga, Spain. Students perform peer review of one or more tasks in these courses, such as the resolution of an exercise, the development of a report or the presentation of a project, which are carried out on the basis of similar statements and/or specifications with well-established rubrics. This methodology allows us to strengthen those concepts that teachers consider key in each of the courses using peer review learning processes based on error detection and observation of the different approaches that students expose when solving problems.

1.3. Structure of the Paper

The rest of the article is organized as follows. Methodology and developed experiments are detailed in Section 2. In Section 3 results are presented and discussed. Finally, our conclusions and future work are presented in Section 4.

2. Methodology

The methodology consists mainly of peer review evaluation of projects, class tests, works, activities, in addition to oral presentations. We have considered the case in which students know who they are evaluating [28]. One of the key objectives in the development of this activity is to ensure that students are able to make value judgments on the work done by their peers according to established criteria, in order to improve their degree perception of achievement of the subject. In order to make this possible, students need to have assimilated knowledge and be aware of what they are trying to evaluate.

The fact of knowing the students on whom evaluations are going to be made can lead to biased scores, depending on the affinity or not with the person being evaluated. It may even be that the rating is influenced by the possible consequences that may occur in personal relationships [28]. Therefore, in this case where the evaluated person is known, it becomes very necessary to have clearly defined and delimited the evaluation criteria, with specific headings for the qualification. In addition, it is convenient that there is an established weighting, where the qualification of the students influences the final grade of the task, but it is not determinant. In this line, we have not considered students weighting as we are on pilot experiences, but it is considered as ongoing work. However, the fact that student assessments have a direct impact on the score is a change in their usual role. It is important that students are aware that this activity prepares them, among other benefits, for the relevant critical thinking development in their upcoming professional life, so that without their involvement, the activity is meaningless.

2.1. Research Context

This study has been developed in the framework of a Teaching Innovation Project (PIE19-209) (https://www.uma.es/formacion/noticias/proyectos-de-innovacion-educativa-2019-2021/, accessed on 30 December 2020) grant funded by the University of Malaga. It has been carried out by a team of assistant professors from different STEM departments at the University of Malaga that have met with a common objective, as different weaknesses were recognized in particular learning points that we consider to be essential in our teaching activities. After researching and documenting it, we identified the peer review approach as an invaluable tool that could be developed in the context of the teaching

innovation call for projects that our University opens every two years. Thus, we decided to elaborate a proposal and this was submitted for evaluation. Then this project was granted one and a half years ago, although our activity on it goes back to January 2018. In order to assist the reader, details of our experiences are shown in Table 1.

Table 1. Summary of experiences.

Nr.	Type	Course	Level	Degree	#	Type of Task	Modality	Grouping	Result Analysis
Experience 1	I	Linear Algebra and Geometry	BSc	Mathematics and Computer Science	77	Worksheets	On-site	3–5 members	Final test score improvement
Experience 2	I	Algebraic Structure	BSc	Mathematics and Computer Science	67	Worksheets	Online	3–5 members	Final test score improvement
Experience 3	I	Statistic II	BSc	Marketing and Market Research	214	Worksheets	Online	Individual	Final test score improvement
Experience 4	II	Wireless Networks	MSc	Telematics and Telecommunication Networks	17	Project Oral presentation	On-site	2–4 members	Slight score deviation
Experience 5	II	Renewable Energies	BSc	Energy Engineering	23	Report review	Online	2–4 members	Slight score deviation
Experience 6	II	Stochastic Models	BSc	Mathematics	11	Project Oral presentation	On-site	Up to 3 members	Slight score deviation

In total there have been 409 students involved in this activity, distributed among the different courses offered by the University of Malaga. This provides a key multidisciplinary character to this work, starting from a relevant sample of students and applying peer review to a varied range of topics.

A total of six STEM courses have been chosen for this study. The peer review methodology had to be adapted to the nature of each of the subjects as well as to the preset teaching plans without disrupting the natural flow of the course. A different instructor is in charge of every experience since they belong to different STEM departments in the same institution (University of Malaga).

This work was motivated by the recurrent difficulty of a considerable proportion of students to acquire the necessary skills and thus solve problems that involve minimum requirements to pass the subjects. In this context, peer review is considered as a reinforcement activity that improves the way in which objectives are achieved. Additionally, given the wide range of possible solutions to science and engineering problems, students can propose different approaches that do not have to be strictly provided by the teacher. We believe that the peer review methodology can help the students to reach different solutions and understand multiple valid perspectives to address the presented challenges.

Finally, it has been observed that on many occasions it is easier for students to understand what their peers want to communicate to us than what the teacher is telling them. That is why a source to reinforce knowledge and contribute to their learning process has to be provided by their peers and we have tried to design a methodology to take advantage of this mechanism.

We propose students that voluntarily participate in this project to correct a series of activities of other classmates. In this way, they will review exercises using a detailed rubric provided at the time of carrying out their own exercises, so that they know the evaluation criteria. The evaluation of the students to their peers will be assessed according to the approximation of their scores to their peers with respect to that given by the teacher. Thus, we motivate the dedication on the part of the students. Moreover, it has to be noticed that this methodology provides a very interesting source of evaluation in the post COVID-19 environment as it provides data for a more enriched and constructive evaluation.

To sum up, we have conducted a series of experiments that contrast how the use of this methodology affects different scenarios with different conditions. In some cases, all students have taken part in the peer review voluntarily and in other cases there are groups in which it has been applied and others in which it has not.

2.2. Research Method

The method applied in this study has been divided into three well-differentiated steps in two types of experiences consisting of:

- Data collection: In this step, data from the students has been gathered. These data are of two different types. First, we used the numerical data of the student's score, both data of final score and data from each of the exercises related to the proposal of our project (peer review). In the Spanish educational system a 10-point scale is imposed, being 10 the maximum score. We have followed it, but it can be applicable to any other scale. Secondly, data has been extracted from the MSc and BSc degrees that the students who have voluntarily taken part in the project give to the peers they are reviewing. The students who take part in the project must provide scores to their classmates, in some cases using a rubric provided by the instructors. In this way, the students are always knowledgeable of the rubrics and their associated items and how they are going to be evaluated. Selection bias consisted in a self-assignment of students to treatment group or control group, since the final exam is identical for all students and is the only evaluation score to be analyzed. However, we notice that there were questions in the exam that were reinforced by peer review activities and students from the treatment group obtained better results. Peer review tasks were focused on reinforcing the learning process regarding critical content of the syllabus. Not only that, but also it allowed students to realize the most common mistakes in the most critical aspects of the academic subject, which provided them with an extraordinary validation tool of the knowledge acquired. Additionally, selection bias plays a major role, since the voluntary nature of the experience makes it so that the most motivated students are those willing to take advantage of this new tool. Nevertheless, some factors need to be considered since only scoring does not guarantee a successful learning process. Among them we are aware of no necessary assessment maturity, not taking assessment seriously or a negative attitude towards the evaluation of these characteristics that can restrain the success of this methodology. For this reason, activities are intentionally prepared by the instructor so that they cannot be solved without having a wide understanding of the resolution process. In other words, judging peers' solutions are not about comparing numerical results but following and reviewing the reasoning process. Instructors have also reported that this has always encouraged students to boost their learning process. Due to the classroom limitations, some courses are divided into different academic groups (shift). For this reason, in several courses the number of students exceeds the permitted limit. Therefore, two or more groups are created. Then all of these groups of the same course are within the paper academic group.
- Treatment of data: All data collected have been anonymized according to the privacy regulation. These data have been contrasted with each other according to their nature, so that in some cases all students have volunteered to take part in the activities related to the peer review and in other cases this has not been the case. For this reason, the analysis in each case has been dealt with differently and therefore data has been treated in a customized way for each one of the experiences.
- Processing results: Advanced software such as Matlab® with statistical tools have been used. Given the potential of this tool, we have obtained graphs that significantly show how the premises defined in our thesis have been satisfied in a tangible way.

2.2.1. Experiences Type I

With these experiences we aim to observe the impact that peer review has on the final score of the course. Students were put into teams to perform different activities in the classroom in order to assimilate basic concepts. The tasks that are being evaluated by peer review consist of solving exercises in which students apply the concepts learned in class following a theoretical approach. For example, the instructor explains the concept of the derivative and its applications and students have to solve a concrete problem that involves

the derivative and that has not been previously solved in class. Therefore, the proposed tasks are very similar to the exercises to be solved in the exam. Afterwards, solutions were exchanged so that students could peer review each other. Finally, the teacher made a final correction of the results and the students' own corrections of their classmates. Accordingly, experiences 1, 2 and 3 have been conducted following a similar procedure so that the impact of peer review has been analyzed.

In these experiences, on-site activities have been carried out. Peer review was not implemented in all exercises as we considered that its application only on selected parts of the syllabus is a more effective way to preserve the appealing character of such a new methodology.

However, we have relied on the background and expertise of the instructor to choose those exercises that deal with fundamental concepts of the course and which, after previous years' experience, students find difficult to acquire. Between 2 and 3 activities have been carried out throughout the course, covering around 30–35% of the syllabus so as not to overload the students.

In addition, in these experiences, each student involved in the peer review has a period of time to carry out the exercises under the guidance of the instructor. These guidelines serve as a reference to accomplish the review of the exercises (between 2 and 3 peers) that takes place during the second stage. The number of exercises in each activity will be between 3 and 5. During this time, the student reinforces the knowledge that he/she has acquired after facing the proposed exercises they knew how to solve. In addition, although the student has the proposed solutions to those exercises, in some cases new possible solutions can be found. Finally, after the correction of the exercises, the instructor supervises all the scores in order to avoid deviations by students who mistakenly give wrong solutions.

2.2.2. Experiences Type II

Experiences belonging to this type are intended to test students' critical thinking and the capacity for objectivity with respect to the teacher. For them, different class tasks are presented and must be evaluated by their own peers following detailed rubrics shown in Tables 2–4. In order to assist the reader, the difference between the score issued by the teacher and the score issued by the peers (students) will be represented graphically so that final conclusions can be drawn. Experiences 4, 5 and 6 have been carried out for this purpose.

In these experiences, we selected activities in the form of projects to be presented by the students, at all times under the instructor guidance. These projects focused on the fundamental topic of the subject while reinforcing other transverse skills such as public speaking, synthesis, slide preparation, etc.

In addition, in these experiences, the students had a detailed rubric prepared by the instructor before defending each of their projects, so that they were aware of the items to be assessed, both by their classmates and by the instructor himself (see Tables 2–4). Before starting, it was proposed that the students review the rubric in depth in order to know how it should be applied and resolve any relevant doubt of the process. From this point on, students began to prepare the project under the supervision of the instructor. When the time came for the presentations, the students were in charge of assessing following both the rubrics and the exhibitions of their classmates' projects. It was the instructor's task to make their own evaluations of the presentations, as well as to review each student's.

Table 2. Experience 4-Rubric.

CRITERIA	4-EXCELLENT	3-GOOD	2-REGULAR	1-INSUFFICIENT
TECHNICAL ASPECTS/ CONTENTS (C)				
Difficulty/originality of the problem posed	The problem and objectives to be solved are highly complex from the point of view of communications and/or have not been addressed in previous cases.	The problem and objectives to be solved are challenging and it is difficult to find existing commercial deployments that cover them.	The problem and objectives to be solved are uncomplicated and it is easy to find existing commercial deployments covering the same scenario.	The problem and objectives are very common, there are many deployments that solve them and with documentation and information available in an open and detailed way in the Internet.
Use of radio technologies	The radio access technologies are perfectly adjusted to the proposed objectives, covering the needs of range, bandwidth, latency, etc. in a cost-efficient way.	The technologies adequately cover the use case although it may involve some restrictions to cover the requirements or is of a high cost (CAPEX or OPEX) with respect to other alternatives.	The radio technologies do not fully cover the objectives. There are other solutions clearly much more suitable to the problem.	The radio technology chosen does not allow the objectives to be covered even partially due to large bandwidth, latency or other limitations.
Architecture	The architecture is appropriate according to the technology, scalable and allows for the coverage of the required area. Its totality is detailed.	The architecture is adequate according to the technology and needs but some important details of it are left out.	The architecture presented does not include important elements of it and/or is clearly inefficient.	The architecture is not suitable for the technologies and/or objectives presented.
Cost Detail (not to consider the efficiency of the solution, only take into account the comm. components)	The CAPEX and OPEX costs of the solution have been calculated in a detailed and precise way for all the elements of the architecture, for an example case and taking into account costs of real suppliers and in comparison with other options.	Cost estimates have been made for most of the elements used and their area.	Unit cost values are indicated, but not system cost values.	No cost estimates are given or they are clearly wrong.
Environment	It takes into account in a detailed way social conditions, electromagnetic compatibility, security, installation and spectrum use license, etc.	It takes into account the main social, electromagnetic compatibility and safety conditions, etc.	It takes into account some social, electromagnetic compatibility, safety, etc.	It does not take into account environmental issues.
FORMAL ASPECTS (F)				
Slides	Covers the topics in depth with details and examples. The visual and technical quality of the material is excellent.	Includes basic knowledge of the subject. The visual and/or technical quality of the material is acceptable.	The content is too basic and the visual and technical quality of the material is poor.	The content is too basic and the visual and technical quality of the material is poor.
Oral presentation	Great clarity, interesting and very well presented	Acceptable exposition, being able to maintain the interest of the audience.	Limited presentation, capturing little attention from the audience.	Poorly presented and did not get the attention of the audience.
Answer to questions	Knowledge of the subject is excellent and responds fluently to all questions asked.	Knowledge of the subject is acceptable and responds well to most questions.	Shows some lack of knowledge or ability to answer questions.	Answers are not answered correctly, has major gaps in basic concepts, and does not correctly define his or her work.

Table 3. Experience 5-Rubric.

CRITERIA	5	4	3	2	1
TECHNICAL ASPECTS/ CONTENTS (C)					
Installation proposed is suitable for its application					
System has been correctly sized					
System has been correctly placed (Orientation & Inclination)					
Converter is suitable for loads					
Loads are realistic for this kind of systems					
FORMAL ASPECTS (F)					
Recommended chapters					
Graphics have proper explanations					
Index of Content					
Index of Figures & Tables					
Appendix & Nomenclature					
Accurate References & Bibliography					

Table 4. Experience 6-Rubric. Mark: 1, 2 (Basic); 3, 4 (In Progress); 5, 6 (Achieved); 7, 8 (Highlighted).

CRITERIA	Possible Aspects to Consider	Score
	TECHNICAL ASPECTS/ CONTENTS (C)	
MOTIVATION/ CONTEXT	- Aims of the analysis and motivation in the choice of the time series. - Explanation of the process of obtaining data, its possible treatment and interest in the time series. - Relationship and comparison with other processes with similar topics.	
IDENTIFICATION	- Models are identified that explain the behavior of the time series. - Appropriate models are proposed from the analysis of the graphics, explaining their meaning. - Suitable models are proposed according to a clear order, without unjustifiably ignoring possible candidate models.	
ESTIMATION	- Estimation of the parameters involved in the model according to the previous criteria. - Application of significance tests for the model parameters. - Use of unit root tests and their consequences. - Formalization of the process in terms of theoretical equations.	
VALIDATION	- Model validation using estimators and residuals. - Different tests application for the validation of the proposed model. - Application of model selection criteria.	
FORECASTING	- Forecasting is applied by means of graphics and in a numerical form, contextualized with data of the process. - The predictions are compared with the observed data.	
SOFTWARE APPLICATION	- Implementation of the basic tools for the modeling framework. - Use of the adapted code according to the features of the process. - Expansion of tools through those available in the software.	
	FORMAL ASPECTS (F)	
GRAPHICS PRESENTED	- Graphics are presented with basic outputs that allow the modeling. - Presentation and explanation of the necessary graphics to support the methodology followed. - Presentation and explanation of the reinforcement graphics with advanced tools to facilitate the monitoring of the presentation.	
METHODOLOGY	- Implementation of all phases of the Box-Jenkins methodology. - Interest of the process for the methodological application. - Clarity and order for the monitoring of the methodology.	
EXHIBITION/ RESOURCES	- Clarity and coherence with the slides and the contents of the work. - It reflects the methodology used, facilitating the knowledge of the whole process until the results are obtained.	
EXHIBITION/ PRESENTATION	- Clarity and order in the development of the contents. - It relates the parts of the presentation, the purpose and conclusions. - Questions are answered showing knowledge of the contents. - It reflects general knowledge on both the Time Series and the statistical methodology used in the modeling framework.	

2.3. Procedure Description and Applications

Peer review to strengthen concepts in students through an active methodology from the teaching and learning process to evaluation. The aim of the project is to involve students in the evaluation process, allowing a review of the material from a critical perspective, so that, seeing the need to analyze different approaches and points of view that may not have considered when performing their task, students will have a more global vision of their

learning in the subject. This vision will allow us to identify possible errors, limitations and/or highlights, see different methods of resolution and also detect when there are successes or improvements to the techniques applied.

In short, the aim of the approach is that students have access to various forms of performance of the same task which will allow them to acquire a deeper knowledge of the subject. When students review projects or tasks of other classmates, they acquire a critical vision of the work, preparing them for their professional future, where any task is subject to public assessment. This is a motivating aspect for the students who see in the realization of this evaluation its application to the real world. This last concession does not intend at any time to discharge the responsibility of the teacher in terms of evaluation and qualification of students, since the teacher must monitor that both the qualification and the evaluation have been made based on objective criteria and, of course, the teacher has the ultimate responsibility.

The procedure is organized as follows. In a first face-to-face session, the knowledge test will be carried out. Students must identify themselves by name in the test that must be given to the teacher. However, in order to guarantee the anonymity of the answers, the name must be able to be replaced by an identification code that the teacher will establish.

The teacher must establish this identification code and associate it with the name of each student. This relationship will only be known by the teacher. The teacher will remove the student's name with the pertinent anonymous identification code. The teacher shall make the appropriate copies, so that each student can evaluate at least two tests from other students. In a second face-to-face session, and after the publication of the corresponding rubric, each student must evaluate the answers of at least two other peers. The possibility of having the rubric in the session is up to the teacher. In this second face-to-face session, the student will record the assessment he or she considers from the other classmates. The teacher will collect the evaluations on a corresponding card, which must contain the name of the student who has carried out the evaluation of the exercise and the code of the student evaluated. The teacher will have to make a definitive correction of the contents and determine how far they deviate from the score issued by the peers. In this sense, a smaller discrepancy between the teacher's and the student's score will guarantee that the student has assimilated the content and that the correction by pairs has been based on objective criteria.

During the academic year 2019–2020, the planned objective of the fieldwork by the teachers involved in this project and the students involved has been fulfilled for the realization of collaborative peer evaluation activities. A total of six experiences have been carried out in multidisciplinary subjects of different scores involving two of the three designed evaluation modalities: anonymous evaluation (the student does not know who he is evaluating) and public evaluation (the student knows who he is evaluating).

Under the mode of anonymous peer review, it is intended to limit the influence of bias due to any type of social relationship between students, deploying a series of protocols and procedures to ensure the anonymity of the contents of the peer evaluation. On the other hand, in the modality of public evaluation students are exposed to real evaluation situations that require the promotion of their critical sense under the application of evaluation validation mechanisms that ensure that the scores really reflect the acquisition of the objectives of the proposed task.

Next, we include a brief description of different experiences developed throughout the academic year 2019–2020. Derived from the multidisciplinary and enriching experiences developed during the last academic year, during the current academic year an exhaustive analysis of the results and information obtained will be carried out in order to obtain clear and concise information on the strengths and weaknesses of this peer evaluation system as well as to identify possible lines of improvement. This will contribute to a restructuring in the final phase of the project, where those improvements identified based on the results obtained in the first phase will be applied, if necessary, and the results obtained will be analyzed again to determine the effectiveness of the innovative proposal. Furthermore,

during the present course, new experiences will be developed that will contribute to improve the quality of the results obtained from the present PIE (Teaching Innovation Project) with respect to the collaborative peer evaluation.

2.4. Experiences

This section presents the six experiences grouped in two different types as we have previously described.

2.4.1. Experience 1

Participants: Students of the "Linear Algebra and Geometry" course in the "Mathematics" BSc and the "Mathematics and Computer Science" dual BSc.

Procedure: Contents included in this experience covers two of the total of four lessons of the course, where the other two followed a classic evaluation approach

The peer review took place in the classroom. The session took one hour and a half. Students were first grouped into 3–5 member teams to solve several activities in one hour. Once they solved the assigned problems, the solutions of each team were exchanged. At that time, the copies of the activities solved correctly were also handed out so that students had a correction guide. The instructor explained one standard way to solve each proposed activity and they appear in the correction guide. However, we are aware that in many cases there are different ways to solve a task, and this is highly valued.

Each group had to correct the activities solved by other groups in the last 30 min of the lecture. At the end of the session, the teacher collected all the activities, both the activities that were done and the corrections made by the students. It was possible to observe a great interest by the students to know if the corrections that they had proposed to their peer's exercises were correct or not. In addition, the attendance level for this sort of activities was very high. The fact of having their own peers at the time of being scored leveraged their motivation. From the 77 students in the group, 32 of them voluntarily performed the peer review task while another 45 students did not.

2.4.2. Experience 2

Participants: Students of the "Algebraic Structures" course in the BSc degree of "Mathematics" and the "Mathematics and Computer Science" dual BSc.

Procedure: As in the previous case, the experience covers two lessons of the total of four. The peer review took place during an hour and a half session. These lessons were held virtually due to the COVID-19 using the Zoom application. This tool allowed the creation of small rooms so that students could be divided into 3–5 member groups. Students spent an hour solving the activities. Afterwards, they exchanged solutions, also virtually, and spent the last half hour of class correcting. Finally, the teacher collected all the activities and corrected them. Since they are mathematical exercises, in many cases there are different ways to solve them. Nevertheless, the correction by the students of exercises solved in a different but correct way from the one provided by the teacher is highly valued. From the 67 students, 29 of them voluntarily participated in peer review activities while another 38 did not.

2.4.3. Experience 3

Participants: Student of "Statistics II" course in the "Marketing and Market Research" BSc degree.

Procedure: At first, the students had to group together and deliver the activities as a group. However, as a consequence of COVID-19, teaching was delivered online and the exercises were carried out individually. In this sense, the teacher created an appropriate task so that students would be able to manage all relevant issues under lesson 1. Specifically, a list of activities was given to the students before solving them in a virtual session. Students had to value both the resolution and the result of the activities of their classmates. From the 81 students in the group, 41 of them performed the peer review task voluntarily while

another 40 students did not. Since class attendance was not mandatory and these activities took place during on-site sessions, some students did not get involved in the experience. Others simply did not want to take part in them because of the additional workload. In addition, 133 students from two other academic groups of the same course did not do the peer review task and serves as a control group.

2.4.4. Experience 4

Participants: Students of the "Wireless Networks" course in the "Telematics and Telecommunication Networks" MSc degree.

Procedure: This experience has adopted a model based on the development of projects whose objective is the definition of the wireless elements, technologies and architectures to be applied in order to solve a real-world use case. The general lines of work are proposed (smart cities, smart buildings, security…) where the specific use is defined by the students (e.g., farm security sensors, healthcare monitoring in a hospital…). The project teams were formed by 2–4 students each.

The evaluation of the projects was based on oral presentations of 10 min by each team. These were performed in front of all the students and a jury formed by the teacher and three other invited members with professional experience in wireless networks.

Hence, from the presentation, the projects get two evaluations: one from the jury and one from the rest of the class. Both evaluations were based on the same rubric (see Table 2). The rubric was known in advance for the students, and the evaluation was gathered online after each exposition through a Google Forms based poll.

2.4.5. Experience 5

Participants: Students in the "Renewable Energies" course of the BSc degree "Energy Engineering".

Procedure: Students taking part in this experience were about to address the final year dissertation where they will be evaluated by means of a project report thesis and its defense.

On the first hand, students were grouped in teams of 2–3 members. Each team had to address a project of an installation based on renewable energies. This project had to be real and accurate, and it had to be properly developed and explained. For this purpose, students received previous instructions on how the report should be written. Technical aspects were explained during lessons in class.

Afterwards each team had to expose their project in a 10 min pitch, but because of the pandemic situation, on campus lessons were reduced to the minimum and virtual teaching was the recommendation. Because of that, an alternative activity was designed. This experience consisted in a peer review process where each student had to revise one project among those developed by the others teams. In that manner, every project would be evaluated by two or three students and the teacher. For this purpose a rubric (see Table 3) was designed and provided to each student so they would evaluate the project.

2.4.6. Experience 6

Participants: Students of "Stochastic Models" course in the "Mathematics" BSc degree.

Procedure: Following the aforementioned methodology an activity was developed consisting of the realization and presentation, by the students, of a project of analysis and forecast of a time series based on real data. For this purpose, groups of up to three participants were formed. Finally, each student evaluated both the work and the oral presentation of the other projects.

For the implementation of the proposed methodology, an evaluation rubric (see Table 4) was created with ten criteria and several aspects to be taken into account. In the evaluation form, open sections were also considered so that the students could include assessments and proposals for improvement, both of the rubric and of the development of the activity itself.

In order to have a comparison tool to assess whether the activity could be considered valid, the teacher also evaluated the projects and their exhibitions in the same way and under the same rubric used by the students.

3. Results

As previously detailed, a total of six experiences have been conducted, which are grouped in two categories. On the one hand, Type I experiences (1–3) aim to give new insights into the effectiveness of peer review, that is, how the application of peer review methodology can affect student performance. To that end we have analyzed the the scores of the final exam of the course as previously done by other authors, such as Amendola et al. [12], Conde et al. [18] and Li et al. [31]. In this way, groups with and without peer evaluation during the learning process have been compared.

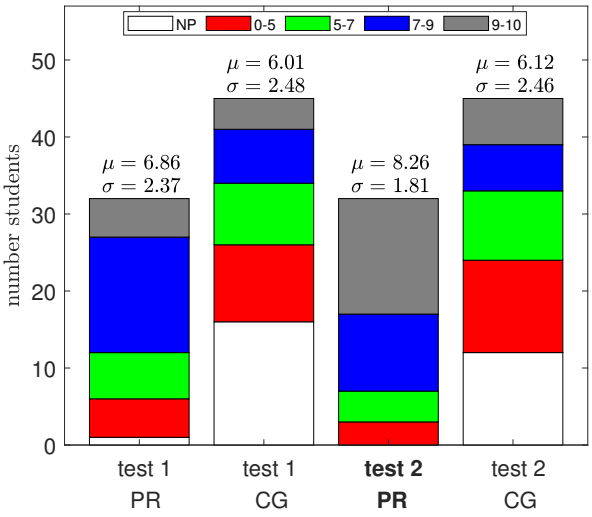
On the other hand, Type II experiences (4–6) focus on evaluating the reliability of the scores provided by peers by analyzing them in terms of their statistical distribution and their relation to the marks provided by the instructor.

3.1. Experiences Type I

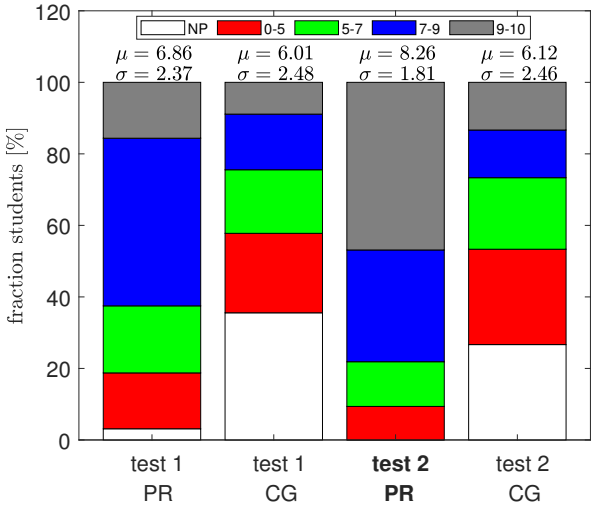
Results obtained from Type I experiences are displayed in Figures 1 and 2 according to the description given in experiences 1, 2, and 3 in Section 2.4. These diagrams display the number/fraction of students whose score is withing specific ranges. NP (standing for Non-Participant) refers to the fraction of students who did not attend to the final test. The rest of categories are defined following a 10-point scale. Since all the experiments were conducted in the context of the Spanish higher education system, it is considered that 5 is the minimum score to pass the exam. Accordingly, the following intervals [0–5), [5–7), [7–9) and [9–10] correspond to no pass, approved, outstanding and pass with distinction respectively.

Regarding experiences 1 and 2 (Figure 1), students were split into two subgroups: peer review (PR) and the control group (CG). As previously mentioned, the selection bias is based on a self assignment by the students themselves. Members of PR subgroup are those taking part in peer review activities during the learning process. On the other hand, members of CG are not taking any sort of peer review activity. In other words, they have followed a traditional learning process. In addition, the final exam of the course is formed by two tests: test 1 is related to the part of the syllabus where traditional learning process is used, whereas test 2 evaluates competences acquired in the second part of the subject (where only member of PR puts into practice peer review). This means that peer review activities have only been deployed by the members of subgroup PR in test 2 (bold in diagrams).

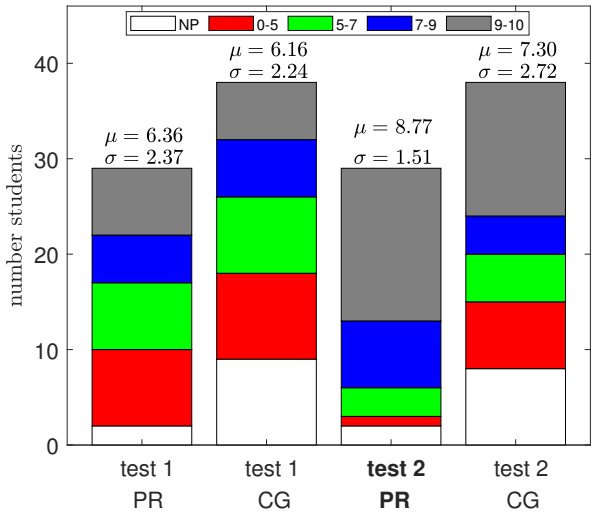
Based on this grouping, a comparison of the different subgroups based on mean scores and their standard deviation is of interest to check if the students' performance improves as a result of peer review activities. Left-hand side diagrams in Figure 1 describe the distribution of scores based on the number of students within each range, whereas right-hand side diagrams do the same but based on the percentage/fraction of students.



(**a**) Experience 1 (number of students).

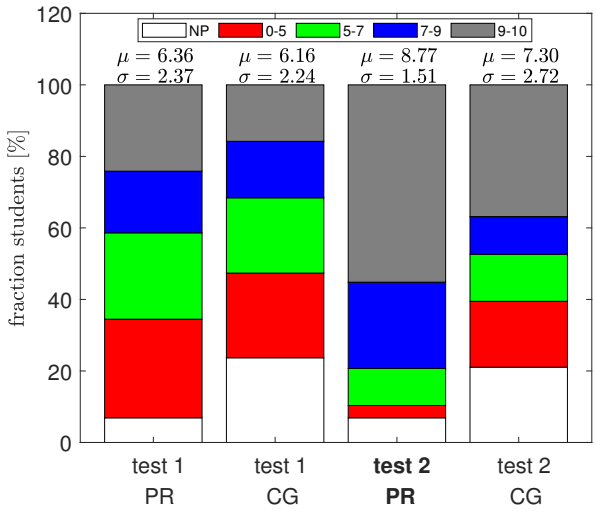


(**b**) Experience 1 (fraction of students).



(**c**) Experience 2 (number of students).

Figure 1. *Cont.*



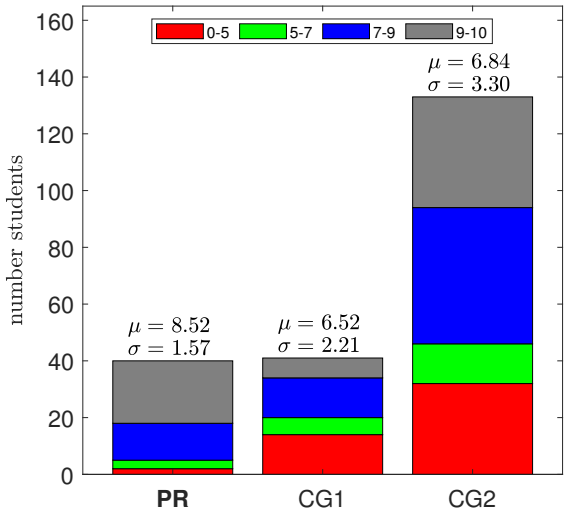
(**d**) Experience 2 (fraction of students).

Figure 1. Score distribution obtained in type I experiences 1 and 2.

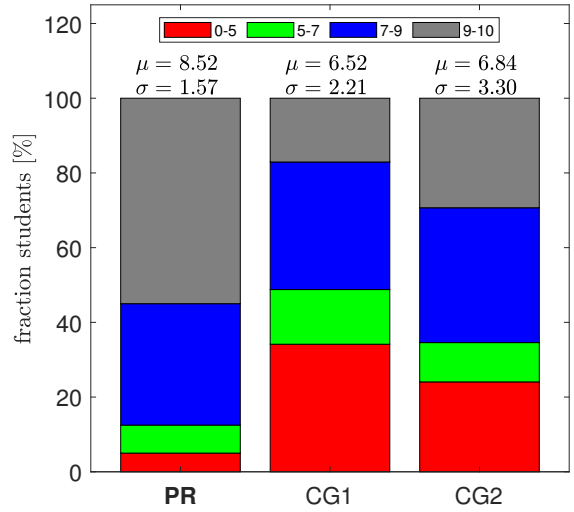
Relevant conclusions can be drawn after from the results compiled after conducting experience 1 (see Figure 1a,b). Based on the mean scores, the control group (CG) obtained similar grades in both tests ($\mu = 6.01 \pm 2.48$ for test 1 and $\mu = 6.12 \pm 2.46$ for test 2). It can be explained since CG members have followed the same traditional learning process for both tests. In contrast, a significant difference has been reported when comparing results between test 1 and test 2 by PR members. Peer review activities allowed an increase in the mean score of test 2 ($\mu = 8.26 \pm 1.81$) vs. test 1 ($\mu = 6.86 \pm 2.37$). This shows that peer review has positively contributed to the learning process in the second part of the course being the process of learning from peer's flaws a key asset.

Experience 2 provides analogous results (see Figure 1c,d). One can observe that peer review activities deployed in the second part of the subject (test 2) contributed to an increase in the average score of PR members by 2.41 points (from test 1 $\mu = 6.36 \pm 2.37$ to test 2 $\mu = 8.77 \pm 1.51$). It is nevertheless noteworthy that results compiled by CG members have also shown an increase between test 1 and test 2 ($\mu = 6.16 \pm 2.24$ vs. $\mu = 7.30 \pm 2.72$) but less significant. This shows that, despite the fact that other factors may affect the average score (some parts of the syllabus may result more complex), the effectiveness of peer review has been proven, as it has shown a consistent improvement in the students performance expressed in terms of their final score.

Regarding experience 3 two figures have been shown (Figure 2a,b). Unlike experiences 1 and 2, only three subgroups have been formed, and a single test has been done covering the whole subject. The first subgroup (PR) is formed by those students who voluntarily decided to take part in the peer review experience (it is displayed in bold in figures). Alternatively, subgroup CG1 is associated to students who did not take part in such activities. It is important to mention that both subgroups (PR and CG1) belong to the same academic group/shift. In addition, subgroup CG2 represents students of the same course but from a different academic group/shift who did not take part in peer review activities (note that due to classroom limitations a course can be divided into different academic groups/shifts). A similar comparison can be set based on the academic results of the three different subgroups. Scores by subgroup PR was 8.52 ± 1.57, which is clearly higher than those obtained by members of CG1 ($\mu = 6.52 \pm 2.21$) and CG2 ($\mu = 6.80 \pm 3.30$). In line with experiences 1 and 2, experience 3 also indicates that students taking part in peer review activities benefit noticeably from the experience. All students have gone through the same final evaluation tests and course syllabus.



(**a**) Experience 3 (number of students).



(**b**) Experience 3 (fraction of students).

Figure 2. Score distribution obtained in type I experience 3.

3.2. Experiences Type II

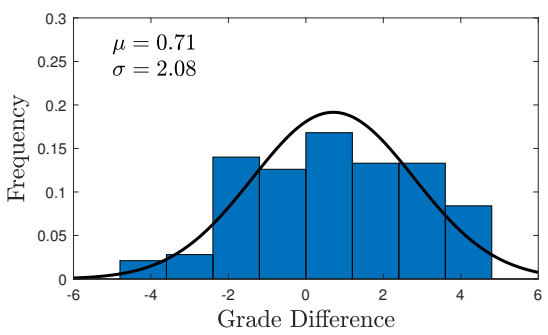
Results concerning type II experiences were assessed by calculating the existing distribution of the score difference [12,30,31] obtained by subtracting the reference-score from the score provided by peers. Here, the reference-score is the one provided by the instructor (experiences 5 and 6) or the average between the score provided by a panel of experts and the instructor (experience 4). A positive difference indicates that the peer's score is higher than the reference-score. In order to unify the criteria, scores will be expressed on a 0–10 scale before calculating the difference.

The items detailed in the rubrics aim to cover most of the competencies playing a relevant role, but they have been grouped into two main categories. The first one refers to items related to the contents (C) of the task carried out by the student group. It basically refers to how students have applied the specific concepts related to the main scope of the course. In contrast, formal aspects (F) refer to whether students have properly applied the available resources and competences to communicate their conclusions and results.

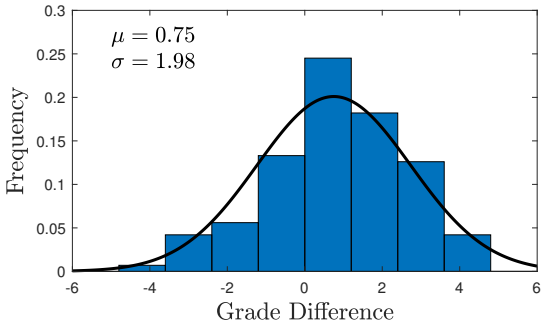
Figure 3 displays the distribution of the score difference grouped in the two aforementioned categories. Left-hand side figures refer to scores related to the contents of the tasks (Figure 3a,c,e). In general terms, scores provided by peers are distributed around the reference-score (i.e., score difference is zero). However, it can be observed that mean

values are slightly positive (from $\mu = 0.71$ to $\mu = 0.08$ in experiences 4 and 5 respectively) meaning that scores provided by peers are slightly higher than the reference-score (set by the instructor). The adjusted underlying Gaussian probability distribution has also been included just for comparison, where the standard deviation shows that the dispersion of the score difference is around two points (0-10 scale) in the worst scenario.

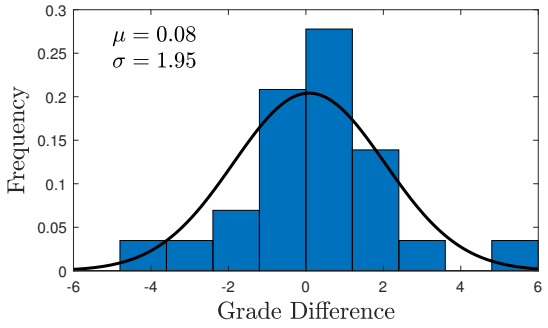
Right-hand side Figure 3b,d,f show the distribution of the score difference concerning the formal aspects (F category). It shows how dispersed the distribution is of the score difference but considering only interdisciplinary competences (not exclusively related to the topic of the course). Analogous distribution is observed in this case, with standard deviation lower than 2 points in all cases and mean values slightly positive. Only experience 5 (Figure 3) has a relatively higher mean value ($\mu = 1.68$ points).



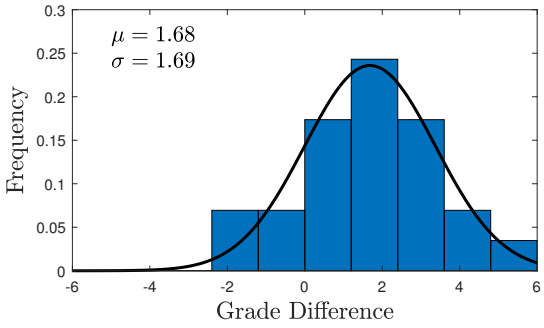
(**a**) Experience 4 (contents-C).



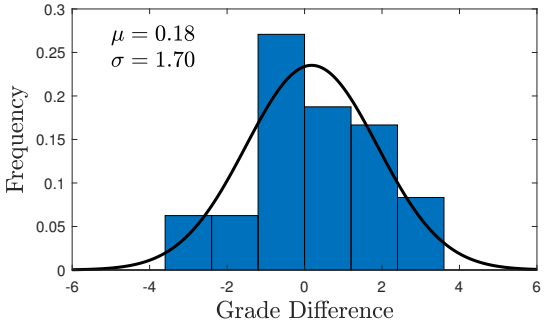
(**b**) Experience 4 (formal aspects-F).



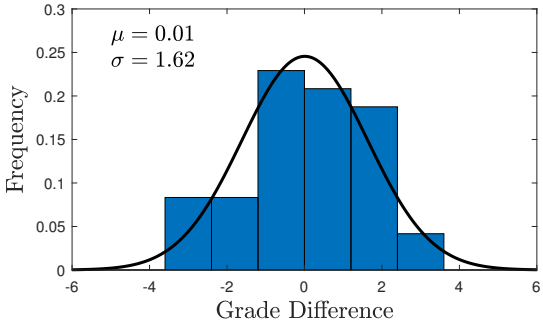
(**c**) Experience 5 (contents-C).



(**d**) Experience 5 (formal aspects-F).



(**e**) Experience 6 (contents-C).

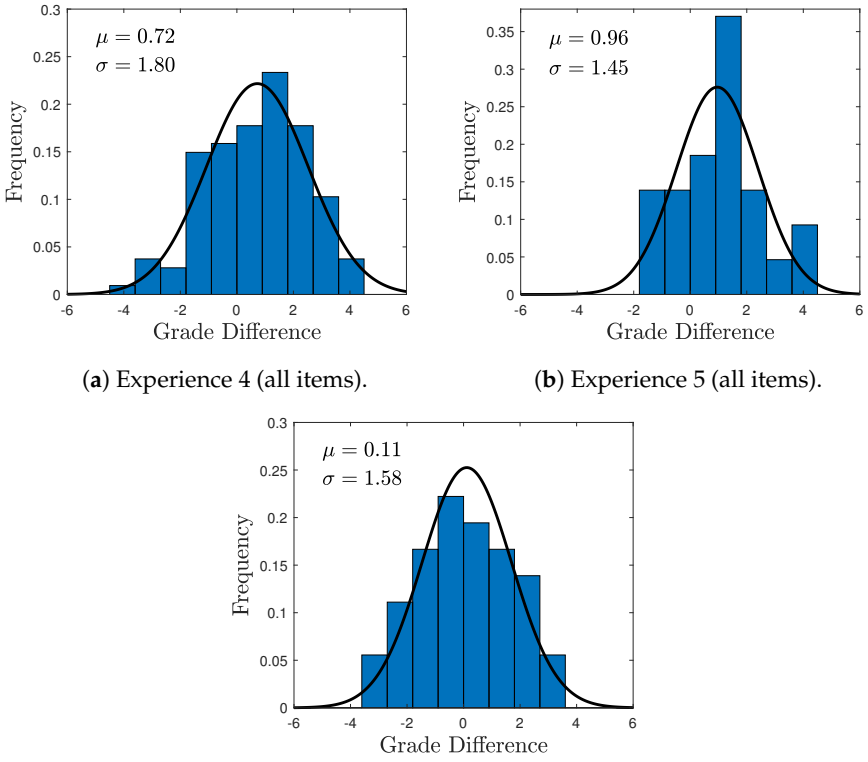


(**f**) Experience 6 (formal aspects-F).

Figure 3. Results of Type II experiences according to rubric items category.

In order to answer the question about if peer review is an effective and reliable method for evaluation, the average of all the items of the rubric scores (for both categories) is represented in a single histogram for each experience. As displayed in Figure 4, a global perspective of the distribution is provided, where the mean value of the peer scores is significantly closer to the instructor's reference-grade. Note that in experiences 4 and 6,

mean values are relatively low ($\mu = 0.72$ and $\mu = 0.11$ respectively). Only experience 4 shows a mean value slightly higher ($\mu = 0.96$). However, regardless of the experience or classification assumed for the evaluated items, dispersion (standard deviation) is enclosed by 2 points out of 10. These results can be considered as reference values for the level of discrepancy and variability between the teacher and student qualifications in the peer review process.



(**a**) Experience 4 (all items).

(**b**) Experience 5 (all items).

(**c**) Experience 6 (all items).

Figure 4. Results of Type II experiences including all the items in the rubric.

4. Conclusions and Future Work

When used for educational purposes, peer review methodology is considered a learning technique where students proactively evaluate the work of other students. In this article, an empirical evaluation of peer review has been carried out in a multidisciplinary set of six science and engineering courses in the University of Malaga in Spain, where more than 400 students were involved. In order to answer the two key questions of this study, experiences have been grouped in two different types: (i) those analyzing the impact that peer review methodology has on the students learning process (effectiveness), and (ii) those assessing students' critical sense and the capacity for objectivity in their provided reviews (reliability).

Regarding the effectiveness of the peer review methodology (first key question), it has been possible to validate how the experience has improved the results of those students who have participated. This has been confirmed for different degrees. Here, it can be highlighted that all experiences show a clear improvement in student performance. This is reflected in the general course scores of the participants, being the increase of more than two points (0–10 scale) in the best of cases and at least of one point but always achieving positive results with respect to the control group. Regarding the second key question, we found that the scores provided by the students are very similar to the score assigned by the teacher. Therefore, students are able to evaluate consistently enough according to our results, confirming the feasibility of peer review as a reliable evaluation methodology. Regardless of the type of experience, this methodology has shown to enhance

the learning process prior to evaluation. Not only do students assimilate contents for their first test, but they also develop a well based criteria to identify the mistakes made by other classmates, encouraging their critical sense, and identifying the more complex concepts. This way, students acquire the ability to identify the most common errors allowing them to complement their knowledge of the course more effectively.

After analyzing the application of the peer review methodology, it can be concluded that all the experiences have successfully performed from both academical and motivational perspectives. In this sense, the motivational aspect is key, especially considering remote education conditions. From our point of view, this fact is crucial to encourage students to participate in these initiatives as they clearly improve their academic performance. Hence, peer review can be a key approach for its implementation in the current pandemic scenario where the use of new technologies has become essential in the educational model. Moreover, peer review seems to be an advisable complement to the traditional evaluation process which is frequently considered one of the weak spots of online teaching. In addition, peer review provides the instructor with an invaluable source of information to support a more accurate evaluation.

As future work, a study on how anonymous evaluation affects the results is proposed. It is expected that friendship bias could be mitigated by deploying a series of protocols and procedures to ensure the anonymous nature of the evaluation process. For example, this can be guaranteed by the random allocation of the exercises to be scored following a double-blind review process. This reduces the likelihood that the answers will contain any sort of information about the author of the question. These can be done during the development of the course in question, either in written form or through any computer tool within a classroom setting. In this context, tests might be individual to help the anonymity of the review process.

In addition, based on our experience, we propose a continuous improvement in the rubrics in order to increase the quality and objectivity of the review process. This will be achieved by the redefinition of their format and instructions, the elimination of the points that can be considered weak and the inclusion of new items that can be interesting for the evaluation. These proposals for improvement of rubrics will be gathered from both the analysis of current rubrics as well as the obtained results accompanied with a survey fulfilled by those students that voluntarily participated in the peer review. Moreover, it has been identified that in some cases the correction of exercises requires an excessive amount of time considering the planned students workload. For these, an improvement is deemed necessary to adapt the amount of exercises to be performed during class in order to dedicate more time to the correction to be performed by the students. Another option being envisaged is to dedicate one session to the development of the activities and another to their correction.

Finally, it is planned to study the impact of the peer review methodology in the same six courses in the next years in order to assess its continued use. Moreover, its application to other courses and fields is also planned in order to widen the multidisciplinary nature of the analysis.

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Abbreviations

The following abbreviations are used in this manuscript:

EHEA	European Higher Education Area
SCL	Student-centred learning
BSc	Bachelor of Science
MSc	Master of Science
MOOC	massive open online course
PIE	Project Innovative Education

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Article

Development and Psychometric Properties of a Scale to Measure Resilience among Portuguese University Students: Resilience Scale-10

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Abstract: Higher education students lack skills to deal in a positive way with the crises inherent to the developmental phase in which they find themselves. However, the complexity of the current global context adds an urgent need for them to be resilient. For this purpose, it is necessary to evaluate their capacity for resilience, which requires the use of instruments that are easy to access, useful, simple, and fast. In this sense, this study aimed to develop and validate a scale to assess students' resilience in the face of adversity. The scale was administered to a sample of 2030 Portuguese higher education students. The results obtained pointed towards a factorial structure composed of two factors named "self-determination" and "adaptability", which showed good internal consistency. Therefore, this scale proved to be a valid measure to assess resilience among the university population. Future studies may consider this variable as an intervention target since it can be a predictor of success in phases of change and crisis.

Keywords: resilience; validity; higher education; resilience scale-10

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1. Introduction

Given the continuous transformation of society and the unpredictability of its future, knowing how to deal with adversities has become an essential competence to survive healthy and with quality. This capacity, called resilience, has gained relevance in scientific research [1–6].

The resilience has been defined from different perspectives: As an interactive concept which is concerned with the combination of serious risk experiences and a relatively positive psychological outcome despite those experiences [7]; as a universal capacity that allows a person, group or community to prevent, minimize or overcome the harmful effects of adversity [8,9]; as the capacity of a dynamic system to adapt successfully to disturbances that threaten the system function, viability, or development [10]; as the outcome from negotiations between individuals and their environments for the resources to define themselves as healthy amidst conditions collectively viewed as adverse [11]; and also as the "ability to use knowledge, attitudes and skills in order to prevent, minimize or overcome the harmful effects of crises and adversities" [2] (p. 167). Therefore, a resilient person, facing a stressful or adverse situation, manages to use his or her personal resources by adopting behaviors that help being successful in that circumstance.

If the complexity of the current global context calls for psychological support for the general population [12], in the case of higher education students, the need for this competence is further justified by the fact that they have to face the crises inherent to the developmental stage in which they find themselves, and the obstacles of the education system itself, as well as the unpredictability of the labor market, in which they will soon be integrated [13–16].

Previous studies point towards the need to promote this capacity among higher education students as it facilitates adaptation to changes and ambiguous situations, the recovery from exhausting and tiring conditions, as well as the proficiency in maintaining a calm, clarity of objectives and guidance in hostile situations. Additionally, it enables the student to think strategically and make appropriate decisions in times of pressure, to perform complex tasks, and to adopt flexible behaviors in problem solving. In this domain, several intervention programs have been evaluated as effective [17–19]. For example, the program You Can Do It! [18], which has been widely applied in multiple Australian schools, presents resilience as the basis for social and emotional learning. Nevertheless, research indicates that the effectiveness of a program depends a lot on the type of activities implemented [19]. Therefore, resilience is a concept that should continue to be investigated, so that the programs made available to young students include pedagogical strategies and resources more oriented to the promotion of this capacity.

In order to assess resilience and determine the criteria for the functioning of the resilient person, several scales have been developed and validated [3,20–25]. Most of the existing scales use mainly clinical criteria, as proposed by Anaut [17,18]: The level of anxiety and depression, the level of social competence, school and intellectual success, and clinical symptoms. Therefore, they focus on behavioral and cognitive assessments, personality traits, and psychological disorders. In turn, Sætren et al. [20] (p. 3) proposed an evaluation through the "three-factor model of personal resiliency", that reflects aspects of the individual's personal experience in three dimensions of his or her own development: "Sense of mastery, sense of relatedness, and emotional reactivity". Another instrument also used to assess resilience is the one by Prince-Embury [25], called resiliency scales for children and adolescents (RSCA), which assesses psychological symptoms and psychological status. RSCA comprises three scales: Sense of control—assesses personal attributes such as optimism, self-efficacy, and adaptability; relationship capacity—assesses trust, support, comfort, and tolerance; and emotional reactivity—assesses sensitivity, recovery, and injury.

Therefore, most of the aforementioned instruments address resilience at the clinical level, with predominance to traumatic and health situations of children and adolescents. Additionally, they are often complex scales in terms of completion and interpretation, which makes both application and accessibility difficult in contexts where a large number of individuals need to be evaluated, as in the case of higher education. In order to bridge this gap, we aimed to develop and assess the psychometric proprieties of a new self-assessment scale—resilience scale-10 (RS-10)—to measure resilience in a non-clinical community. More specifically, the purposes of this study were to (i) develop a brief measure of resilience appropriate for university students; and (ii) examine the factor structure and reliability of this scale.

2. Methods

2.1. Development of the Portuguese Version of the RS-10

This study consisted of two phases, beginning with the scale development phase aiming at identifying the appropriate items to include in a self-report measure. A set of items related to resilience was collected, considering the following parameters: Knowledge obtained in the literature; objectives of the instrument to be built; population to be evaluated; dimensions of the construct to be evaluated; and behavioral aspects of the construct to be included in the evaluation [26]. Additionally, in order to define the RS-10 items, we used as a reference the questionnaires developed by Grotberg [8,26] and Anaut [1,19]. Based on this process, 30 initial items were obtained. These 30 items were presented to a panel of experts with seven researchers/university professors in the areas of psychology, education, and management, obtaining a reduced final version including only 10 items. The 10 selected items were included since they were more directly related to the ability to deal with adversities in daily life, without a focus on traumatic situations. This version went through a process of spoken reflection carried out with a class of 3rd year students from a private university in Porto, consisting of 22 students (7 male and 15 female). These

participants were instructed to report their subjective perception of personal skills to face adversity. Each item was answered using a 5-point (1 = never; 2 = rarely; 3 = sometimes; 4 = almost always; 5 = always) response scale, so possible scores ranged from 10 to 50. Higher scores indicated a higher level of resilience. The application of the questionnaire lasted approximately 10 min and, subsequently, questions related to the instructions for completing the instrument, suitability of the included items, order of the items, and eventual doubts related to the semantics were discussed with the students (see the final version in Table 1; see also Appendix A). Thereafter, the scale's psychometric properties were assessed using a sample of Portuguese higher education students.

Table 1. Description of the items of the resilience scale-10 (RS-10).

Item	Portuguese Version	English Translation
1	Sinto que me conheço bem.	I feel I know myself well.
2	Gosto de mim como sou.	I like myself just as I am.
3	Julgo ter capacidades para ser bem-sucedido na vida.	I think I have the necessary skills to be successful in life.
4	Sinto-me bem com o corpo que tenho.	I feel comfortable with my body.
5	Sinto que tenho uma boa autoestima.	I feel I have good self-esteem.
6	Tenho total confiança nas minhas capacidades para resolver os meus problemas.	I have total confidence in my skills to solve my problems.
7	Tenho conseguido superar as adversidades que a vida me tem colocado.	I have been successful in overcoming difficulties in life.
8	Consigo minimizar os efeitos negativos das adversidades.	I manage to minimize the negative effects of difficulties.
9	Assumo os meus problemas, dando-lhes a importância que têm, sem os subvalorizar ou sobrevalorizar.	I take on my problems, giving them the importance they have, without undervaluing or overvaluing them.
10	Quando uma situação não é passível de ser mudada, aceito esse facto com serenidade.	When a situation cannot be changed, I accept that fact with serenity.

2.2. Validating the RS-10: Sample

The sample included 2030 Portuguese university students over 18 years old (M = 21.11; SD = 2.00; range: 18–26 years) and the majority were female (77.1%). Students were recruited from several Portuguese Higher Education institutions. Most university students were based in higher education institutions located in the North of Portugal (51.5%). Participants attended different training areas, namely social sciences (59.8%), education, health and tertiary services (33.1%), and exact sciences such as engineering, computer science, mathematics, building and agriculture, and transformation industry (7.1%). Among the students, 71.8% were undergraduates and 28.2% were master students. This study has been carried out in accordance with the Declaration of Helsinki and informed consent was obtained from all the participants.

3. Data Analysis and Results

3.1. Properties of Items

A preliminary analysis was conducted in order to assess descriptive statistics, normality, and non-multicollinearity at the item level (see Table 2). The mean response for the 10 items was 3.62 (SD = 0.20). No deviations from the normal distribution were found, as the kurtosis and skewness scores for each item fell within -2 and 2. All the items presented significant positive corrected item-total correlations ($\geq$0.42). The internal consistency of

the total scale was good (α = 0.866) and there was a low variation in reliability if items were deleted. All inter-correlations among all the items were below 0.65 suggesting no multicollinearity. Based on this, all the items were retained from subsequent analyses.

Table 2. Descriptive statistics (n = 2030).

Item	M	SD	Skewness	Kurtosis	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	3.76	0.86	−0.481	0.205	0.505	0.860
2	3.82	0.84	−0.441	−0.120	0.682	0.845
3	3.80	0.73	−0.268	−0.202	0.593	0.853
4	3.60	0.98	−0.498	−0.001	0.552	0.857
5	3.49	0.89	−0.469	0.183	0.705	0.843
6	3.54	0.83	−0.149	−0.111	0.686	0.845
7	3.92	0.74	−0.390	0.188	0.525	0.858
8	3.49	0.79	−0.140	0.189	0.598	0.852
9	3.54	0.87	−0.125	−0.202	0.565	0.855
10	3.25	0.86	−0.040	0.020	0.420	0.867

3.2. Factorial Validity

To test the factorial structure of the RS-10, a combination of the principal components analysis (PCA) and confirmatory factor analysis (CFA) was conducted. The sample was randomly split into two samples through the randomization function on the Statistical Package for Social Sciences, version 24 (SPSS Inc., Chicago, IL, USA), resulting in 2030 observations in total, 791 for the PCA and 1239 for the CFA.

PCA using the oblique rotation method suggested a two-factor structure. The Kaiser-Meyer-Olkin (KMO) measure presented a value of 0.897 and Barlett's test of sphericity was significant (χ^2 = 3412.112, $p < 0.001$). Factor 1 comprised items 1, 2, 3, 4, and 5 (5 items), which we termed as "self-determination", based on the three sources of resilience features labelled by Grotberg [8]. Factor 2 included five items (6, 7, 8, and 9, 10), which we termed as "adaptability". These two factors explained together 60.70% of the total variance. Table 3 shows the factor loadings (>0.60) and communalities (>0.40). Additionally, a good internal consistency for each factor was estimated (Factor 1: Cronbach's α = 0.843; Factor 2: Cronbach's α = 0.813).

Table 3. Factors extracted from the principal components analysis (database 1; n = 791).

Item (Item No.)	Factor 1 Self-Determination	Factor 2 Adaptability	h^2
1	0.636		0.418
2	0.866		0.743
3	0.734		0.576
4	0.854		0.647
5	0.774		0.743
6		0.619	0.657
7		0.730	0.568
8		0.792	0.673
9		0.786	0.607
10		0.705	0.437

The two-factor model derived from PCA was then cross-validated. Mardia's kurtosis coefficient of 20.95 with a critical ratio of 23.80 indicated that the data were multivariate non-normal. Therefore, CFA was performed using the maximum likelihood estimation (ML) with bootstrapping (1000 resamples) to generate accurate estimations of standard errors with accompanying confidence intervals (bias-corrected at the 95% confidence level). To assess the overall model fit, we use the following parameters: Root mean square error of approximation (RMSEA), comparative fit index (CFI), and the standardized root mean

square residual (SRMR). The criteria for an acceptable model fit were CFI $\geq$ 0.95; RMSEA $\leq$ 0.10 [27], and SRMR $\leq$ 0.08 [28]. The chi-square test (χ^2) was reported, but not used to check the model fit due to its sensibility to large samples [29]. Data obtained from the CFA showed that the two-factor model fitted well descriptively (CFI = 0.957; RMSEA = 0.068 (90% CI 0.059–0.076); SRMR = 0.040). All the standardized factor loadings (see Figure 1) of the item parcels were statistically significant showing that question items were good indicators for each factor.

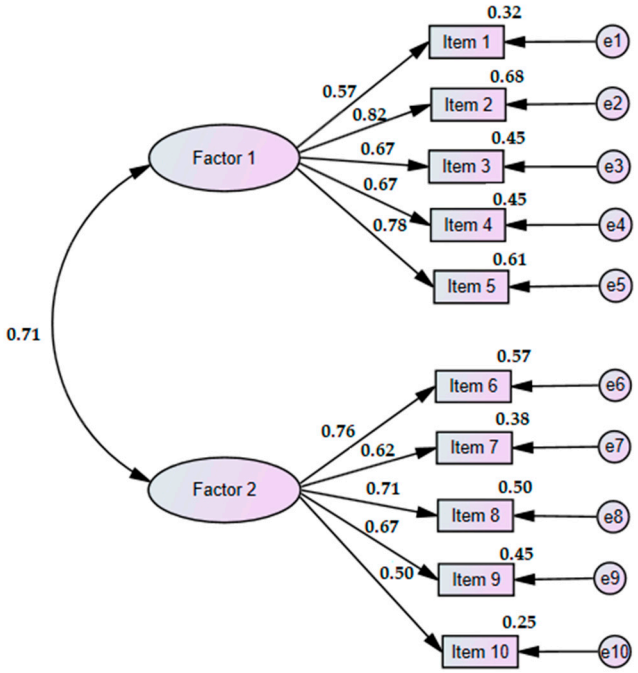

Figure 1. Confirmatory factor analysis: Two-factor solution using a part of the sample (database 2; n = 1239).

4. Discussion and Conclusions

Universities normally have to prepare students to face the multiple difficulties they have to face, both in academia and in the subsequent period of integration in the labor market. However, there are deficiencies regarding the acquisition of skills appropriate to face these challenges [16,30–32]. In times of crisis, as experienced globally today, these are even more evident.

In order to carry out an effective intervention in this domain, it is important to evaluate each student individually in order to activate different strategies for them. This argument supported the need to develop a brief and accessible measure for the assessment of resilience in higher education students identifying the degree of their ability to cope with adversity. Our analysis showed that RS-10 is a valid measure and can contribute to the understanding of the perception of personal skills to face adversity among university students. The scale demonstrated a meaningful and strong factor structure, with items effectively measuring the factors, as shown by the loadings. According to the results, the two-factor model identified in the factor analysis indicated that RS-10 can capture the dimensions of self-determination and adaptability that adequately summarize resilience.

With self-determination, despite the difficulties, obstacles, discouragements, and failures, the individual is sure to complete the previously outlined tasks. Therefore, self-determination allows goals to be achieved and personal projects and ambitions to be realized. In addition, according to several authors, both from the perspective of clinical psychology, organizations and human resources management, self-determination is decisive in carrying out projects, despite the obstacles [33–37].

In turn, adaptability means the ability to change, whenever necessary, the strategy in order to achieve the previously determined objective. As such, it presupposes mental flexibility and emotional plasticity in order to better face unpredictable and unexpected situations. This is a construct that explains the success of those entrepreneurs who identify opportunities and implement projects. Furthermore, it is a characteristic of societies where innovation predominates, such as the current one we live in. Moreover, according to recent research, flexibility is an essential construct to integrate work teams, to lead people in organizations, and to maintain adequate levels of health and well-being [36,38,39]. Similar to other scales, RS-10 has good internal consistency (α = 0.866), with the factor referring to self-determination showing a Cronbach's α = 0.843 and the factor relating to adaptability revealed a Cronbach's α = 0.813. For example, the Portuguese version of the resilience scale of Wagnild and Young [19], composed of 25 items, which evaluates adolescents presented a Cronbach's alpha of 0.86, and the Brazilian version presented a Cronbach's alpha of 0.80 [23]. In turn, "The Multidimensional Teachers' Resilience Scale" [40] presents the following Cronbach's alpha values: Motivational = 0.78; emotional = 0.72; social = 0.74; professional = 0.75. Furthermore, the original version of the Brief Resilience Scale [18] demonstrated good internal consistency, with Cronbach's alpha values between 0.80 and 0.91. Although the RS-10 shows promising psychometric properties, the scale's overall validity needs to be interpreted in the light of potential limitations. First, the main limitation of this study has to do with the sample, which is only Portuguese, thus we suggest a transcultural validation. Furthermore, the Portuguese version of this self-reporting tool must be translated and validated in other languages. Second, there was no assessment of the reproducibility/repeatability. In addition, an important next step is to assess the convergent validity of the RS-10 through the correlations of the scale with theoretically related constructs such as self-efficacy [33,40] and self-esteem [41,42].

Perceived self-efficacy while as a positive belief allows you to carry out new or difficult tasks in order to obtain desired results. This vision of self-confidence, associated with self-control allows us to deal with stress-inducing situations and promote resilience.

Overall, the RS-10 was developed with input from university students and is a quick-response instrument appropriate for use across different training areas and degree levels. However, the generalizability of the study results should be better established in future studies in additional settings. Despite this, the study presents opportunities for empirical studies in the field of resilience and we believe that the use of this instrument in clinical practice may contribute to intervene effectively next to students, promoting their capacity for self-determination and adaptability, which are crucial to face the adversities inherent to human nature and the evolutionary dynamics of the history of society.

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Appendix A

Table A1. Resilience scale-10 (RS-10) (Jacinto Jardim, Anabela Pereira, and Ana Bártolo, 2021) *.

		1	2	3	4	5
1	I feel I know myself well.					
2	I like myself just as I am.					
3	I think I have the necessary skills to be successful in life.					
4	I feel comfortable with my body.					
5	I feel I have good self-esteem.					
6	I have total confidence in my skills to solve my problems.					
7	I have been successful in overcoming difficulties in life.					
8	I manage to minimize the negative effects of difficulties.					
9	I take on my problems, giving them the importance they have, without undervaluing or overvaluing them.					
10	When a situation cannot be changed, I accept that fact with serenity.					

The following sentences refer to a variety of skills one may think to possess to a smaller or larger degree. Please rate each sentence considering how frequently you think in the way it describes, using the following rating scale: 1 = never; 2 = rarely; 3 = sometimes; 4 = almost always; 5 = always. * Authorization to use this instrument should be asked from jacinto.jardim@uab.pt.

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Higher Education and Employability Skills: Barriers and Facilitators of Employer Engagement at Local Level

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Abstract: This research examines the barriers and facilitators to employers' engagement with higher education institutions. The data were collected through interviews with a set of employers (n = 19) in the Northern region of Portugal, V.N.de Famalicão, in 2019. We begin by exploring employers' engagement activities as a potential solution to address local-level skill problems. Empirical evidence suggests that the engagement activities are mostly passive as firms use higher education largely as a recruitment channel. The differences in organizational goals and culture are the most cited barriers to the lack of more active engagement. Some efforts have recently been made to strengthen the ties between higher education and employers, notably through a local multi-stakeholder partnership as a potential broker. However, it will take time for this to bear fruit and contribute to reducing skill gaps and shortages. The data show that despite employers' apparent willingness, more effort must be made to encourage active engagement.

Keywords: higher education; employers' engagement; employability; multi-stakeholder partnership

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1. Introduction

In recent decades, the collaboration between higher education (HE) and industry has grown significantly [1] fueled by marked changes in the modes of knowledge production and innovation [2,3] as well as increasing societal demands and expectations from higher education institutions (HEIs). This collaboration is based on the recognition that HEIs are an essential source of technology, innovation, and human capital [4]. Under the label of a third mission, HEIs are expected to interact with firms at the national and regional levels to promote innovation and competitiveness in the knowledge economy [5].

Only more recently have academics started to pay attention to other forms of collaboration regarding graduates' skills and training [4,6], namely in curriculum design and delivery [7], and in promoting employability skills [8]. Our study adds insights to this research agenda by examining the employers' perception of the barriers and facilitators to engaging with HEIs. More specifically, this research focuses on the engagement activities implemented by employers to develop employability skills and explores the factors that facilitate or hinder such engagement. These issues are raised by HEIs but also by employers themselves in the literature. This is a timely issue in the context of massification of HE and the skill shortages and gaps reported by employers worldwide; however scientific research is still scarce and geographically limited.

Graduate employability has become one of HE's institutional missions and it has been pursued through different means both inside and outside the classroom [9,10]. HEIs have been pressured to provide graduates with skills that match the economic and labor market skill needs and foster their employability [11,12] in a context of rising graduate unemployment levels and persistent skill problems and gaps reported by employers in different settings. The employers' engagement with HE in education and training has been promoted as a vehicle to bridge the divide between the supply and demand of higher-level

skills [13,14], foster graduates' employability, and reduce skill mismatch, thus providing employers with a timely supply of required skills in the economy.

However, in spite of the growing interest in both graduate employability and the engagement between employers and HEIs in the development of skills and training, relatively little academic research has been undertaken on the types of engagement activities developed or the factors that facilitate or hinder them [13–15]. In addition, the literature focuses on few national cases, such as the UK and Australia; research from other European countries is remarkably scarce. Furthermore, the perception of employers deserves proper scrutiny since it provides HEIs with information on the barriers and facilitators to developing engagement. This paper contributes to this literature by attempting to answer the following questions: In which activities do employers engage with HE? What are the major obstacles and facilitators of this engagement?

The empirical analysis draws on qualitative data collected in 2019 through interviews with a set of employers (n = 19) from a city that has developed a multiple stakeholder partnership aimed at connecting different local stakeholders to promote employability, entrepreneurship, and innovation in the region. We have therefore studied employer engagement at a local/regional level in order to ascertain the extent to which this type of partnership fosters closer ties between HE and employers. This qualitative material was examined through content analysis which allowed us to categorize the skill problems faced by these employers at the graduate level, the engagement activities which they develop with HE, and the drivers and barriers to those engagement activities.

The rest of the paper is organized as follows. The next section provides an overview of the literature on employers' engagement with HE in education and training and the role of HE in developing employability skills, a brief overview of the national and regional contexts regarding HE as well as of the local partnership implemented by the city council. Section 3 is devoted to the methodology before reporting the empirical findings in Section 4. Finally, Section 5 provides a discussion of those findings as well as some policy implications.

2. Theoretical Background

2.1. Tackling Skill Problems through Employers' Engagement with Higher Education

The cooperation between higher education institutions (HEIs) and firms has grown significantly in recent times [1,4] fueled by increasing global competition, changes in modes of knowledge production and innovation as well as in the roles attributed to higher education (HE) by policy-makers and societies. This collaboration is expected to provide benefits to different stakeholders [16] by increasing firms' innovation and competitiveness in knowledge economies [5], improving graduates' employability [8], and providing new streams of financing to HEIs in the face of decreasing budgets [17]. Academic interest in university–business collaboration has thus increased dramatically [1] along with the recognition of HEIs as an essential source of technology, innovation, and human capital [4] in the triple-helix model of knowledge production [2] and its subsequent theoretical revisions [3].

However, academic interest has focused mostly on R&D and related activities [1], while collaboration with the development of skills has received less attention [4,6]. The literature on employer engagement attempts to fill this gap but it is mostly limited to a set of countries. Although people may interpret employer engagement with HE in training and education in different ways [18], it essentially comprises responses that help the upskilling of workers or the development of tools that enhance employability [19]. It is reported in the literature that employability is often assumed to be synonymous with work-readiness [12] and HEIs are trying to involve employers to prepare graduates for the world of work. The move towards making employers insiders and key actors in transforming employability into graduate employment [20] has only emerged since the 1990s and it aims to both improve graduates' employability prospects and provide a better response to economic and labor market imperatives [9] by promoting closer ties between the supply of skills and labor market demand.

Employer engagement may be enacted in different forms and through various activities, notably information exchange, internships and using HE as a recruitment channel, participation in job fairs, assessment of the quality of graduates, training opportunities, advice on curriculum and courses, co-design of certain courses, participating in the governance bodies of HEIs and co-funding as a partner.

Some authors further distinguish between "active" and "passive" forms of engagement [13]. A more "passive" engagement involves a simple market transaction and focuses on the acquisition of HEIs' products and services. Examples of the latter may be found in information exchange activities where employers turn to HE to provide information to access the best graduates [21], participation in job fairs [22], or through graduate recruitment [18]. In the context of information exchangers and recruiters, employers are viewed as passive stakeholders that provide information about skills and take advantage of channels to access the most skilled candidates.

Other initiatives imply a more "active engagement", which involves collaboration and the definition of what is being delivered by higher education [13] both at the undergraduate and graduate levels [23] as well as in lifelong learning [4]. A more active engagement allows firms to have far greater influence on the supply of skills and thus contributes to reducing skill problems. Active forms of engagement include, for example, work-based learning, which is often incorporated in the HE curriculum [14,24]. Work-based learning is essentially a partnership between employers and HE institutions to deliver courses and provide students with work experience opportunities [25] and has been found to provide all stakeholders with the most potential benefits [24].

The design, delivery, and assessment of tailored courses [26] is a further example of active engagement. Ref. [27] (p. 2010) label it an "anticipative strategy", which indicates that employers participate in the supply of skills; they work with universities to conceive courses and expect HEIs to provide them with bespoke graduates. Finally, some employers participate in one or more of the governing bodies of HEIs. Once again, this helps employers influence the supply of skills as advisers [28], but according to ref. [29] (p. 2007), it should also involve their financial contribution. Co-funding aims to reduce public expenditure and fosters higher education expansion. However, [10] found evidence of employers' persistent unwillingness to make financial contributions to the development of higher education programs.

2.2. Barriers to Engagement: Higher Education Institutions and Employers

Another stream of the literature examines the employers' engagement with higher education in order to make this interaction more efficient with a win-win outcome. Under the label of barriers and facilitators [14,15,25], this stream of literature focuses on issues that stakeholders from HE and employers raise in order to facilitate the engagement activities and outcomes.

Available literature provides a set of cultural and structural barriers faced by both HEIs and employers [13,18,30]. Barriers within HE refer to the cultural mismatch that often reduces the willingness to engage with employers to ensure the supply of suitable skills. It is said that HE has a certain disdain for business-like activities and places a strong focus on academic activities. Communication difficulties are another widely reported as employers and HE lack a common language.

Some barriers seem to be structural because they relate to the HE system, notably: the disciplinary-based curriculum; the adaptation of pedagogical methods; lack of flexibility to provide tailor-made courses or curriculum; timing of the response to requirements; or poor customer services. In sum, higher education's response needs to meet, rather than conflict with, the employers' and learners' needs in order to obtain a strategic fit.

Additionally, studies have cited the need for an appropriate learning package, that is, higher education should build or adapt training to better fit the employers' specific needs. This often involves bespoke courses and of course rejects the one-size-fits-all programs. However, HE often has insufficient information about employers' skill needs

and engagement involves a trade-off between costs. Ref. [18] note that engagement is costly and risky for HEIs so they may prefer to look for alternatives or prioritize other activities. Moreover, academics' engagement activities are currently not generally acknowledged in career progression within academia [4] and thus often result from sporadic and informal contacts [31] that are not institutionalized.

Employers also impose barriers to engagement. Firstly, the nature and intensity of employers' engagement with HEI vary, notably in line with their workforce composition and specific skill needs, their product or service, and the market competition [13]. Secondly, it is necessary to have a culture of learning and perceive engagement as an investment; whereas the business strategy is often to pursue immediate profit, the benefits of engagement take time to become evident [18]. Thirdly, not only do employers find it difficult to enumerate skill requirements but these may change over time [9], and their main demand is for soft skills and sound work attitudes [23]. Finally, engagement is easier when employers need graduates from certain fields of education, notably engineering [32], chemistry, or health [13].

The reported barriers indicate that a cultural fit between organizations is required from the outset, and it not only calls for changes in work practices and mindsets on both sides but also a share of values. Ref. [19] (p. 2013) highlights the tension between entrepreneurial and academic languages and this creates barriers to collaboration. The literature therefore also examines what facilitates engagement.

2.3. Facilitators of Engagement: Higher Education Institutions and Employers

The HEIs are faced with two interrelated issues. On the one hand, they must proactively encourage engagement by approaching employers, involving them in learning, and providing information about the benefits [33]. It is essential that HEI and the employer develop proper communication and a shared understanding [18]. On the other hand, the system itself needs to be adapted. Ref. [25] (p. 2015) stress that staff from all levels must be enthusiastic about the engagement, in particular in the case of workplace learning.

Employers have a selective approach to HEIs and trust is one of the major issues. For example, the willingness to invest in skill development depends on the employer's knowledge about the programs supplied by the HEI [30]. Alumni can also be used to build a bridge with the HEI to ensure that collaboration is beneficial. The literature documents the fact that the gratitude towards the academy felt by alumni impacts their willingness to engage [34]. Employers may also develop collaboration with individual academics and follow them across HEIs [13]; that is, they mostly interact informally and this means alumni play a decisive role.

On the other hand, employers prioritize the geographical proximity of HEIs [35]. Geographical and social proximity between HE and firms may help in informal relations and information collection [13]. Furthermore, ref. [15] note that engagement is facilitated by the ability to sustain the partnership. This entails equality among partners, but the complexity of this varies in line with the number of members involved; small partnerships are easier to manage, while larger ones require more clearly defined roles.

Employers' engagement with HE is therefore far from straightforward [19] and involves a continuum that goes from an understanding of specific employers' skill requirements as well as the different levels of skills of students and employees to the implementation of mechanisms to develop such skills. All this process requires a culture of trust and commitment to the defined goals; engagement of skilled staff to interact with employers; flexible systems and working methods adapted to the diverse workforce. Only when these conditions are fulfilled do they work as facilitators; otherwise, they function as barriers and invalidate or contribute to making the engagement inefficient. Ultimately, both the decision taken by employers to meaningfully engage with HE and the potential results of that engagement will depend on their assessment of the perceived costs and benefits of that engagement [13]. Some argue that engagement should involve public investment [36],

while others suggest there should be multiple funding sources as they facilitate engagement and acknowledge the relevance of the activities [37].

In sum, in spite of the growing interest shown by different stakeholders in graduates' employability and particularly in the collaboration between employers and HEIs in actual skill development and training, relatively little academic research has been conducted on the types of engagement activities developed, the factors that facilitate or hinder those activities, as well the perceptions of both HE professionals and particularly of employers about these relationships [10,38,39].

A profusion of policy reports have been written at the behest of governments [40] or employers' associations [14] and in some countries, namely the UK and Australia, a number of academic studies have already been made on this subject [41]. However, literature is scarce for other European countries, although some have made huge investments in HE. Furthermore, to the best of our knowledge, there are still no studies in the academic literature on the employers' perceptions of engagement or the factors that facilitate or impede engagement or make it more efficient.

2.4. The National and Regional Contexts

At the national level, Portugal has made substantial investments and progress in both HE and vocational training in recent decades. There has been a trend of massification in HE since the 1990s, with a sharp increase in enrolment rates from around 157,000 students in 1990 to almost 400,000 in 2019. Over roughly the same period, enrolment rates among 30–34-year-olds have also more than doubled, going from 15.1% in 1992 to 36.2% in 2019 and drawing close to the EU average which stood at 40.3% in 2019 [42]. Other recent trends have seen the diversification and differentiation of the system with the expansion of the private and polytechnic subsystems, and the adoption of the Bologna model in 2006 and of a managerialist reform in 2007 that brought Portuguese HE more in line with the trends in Europe and beyond [43].

Over this period, post-graduate and doctoral enrolment [44], as well as research activities, also increased substantially along with research outputs at the system level [45]. On the other hand, the Portuguese education and training system has been found to be excessively centralized, leaving little room to accommodate regional needs [46,47]. Recent legislation has acknowledged the potential benefits of decentralization and has tried to promote the greater involvement of local and regional authorities and stakeholders in addressing the specific skill needs of sub-national economies. However, up until now, the engagement of these local actors has been mostly limited to advice or consultations initiated by the central government [47].

The relatively sparse and fragmented literature on employer engagement with HE in education and training in Portugal has reported somewhat mixed findings. Ref. [39] (p. 107) acknowledge that the collaboration between employers and HEIs is at an embryonic stage, and this is a pervasive feature. Some authors report examples of a variety of activities of engagement, including the design and delivery of courses and shared governance [28]. Nevertheless, passive forms of engagement, such as hiring candidates or job advertisements [28] and internships [48], are widespread among employers in Portugal.

Given this low level of cooperation, a regional multi-stakeholder partnership, Famalicão Made IN, was formed by the city council of V. N. Famalicão with the aim of connecting different local stakeholders to promote employability, entrepreneurship, and innovation in the region through suitable responses from education and training systems. V. N. Famalicão is in a small but vibrant industry-based region, ranking third in the country's export volume and 2nd in gross added value in manufacturing industries [49]. The main industrial sectors include textiles, metallurgy/machinery and polymers (namely for use as automobile components), and agri-food industries and the unemployment levels are traditionally below the national average. Although the region has a few large industrial firms, namely in the textile and automobile components sectors, the majority are small and medium-sized firms in keeping with the typical profile of firms in Portugal [50].

In the region, there are four HEIs, two universities, one public and other private, and two public polytechnics. The universities are more generalist in what they offer (but with a strong component of engineering degrees) while the polytechnics are more vocational in nature (as is usually the case for polytechnics in the Portuguese system) and with a stronger focus on industry-related degrees. Not surprisingly, these institutions in the more immediate vicinity are the ones with whom the firms in our sample will develop greater ties both for recruitment and R&D purposes. Other institutions in the wider Northern region with whom our firms also develop some ties include also public and private universities and polytechnics.

The primary role of Famalicão Made IN is to build bridges between employers and other actors, such as education and training institutions at all levels, local employment services, municipal and intermunicipal institutions, and ultimately to mediate the relationship between local actors and national policymakers. In the context of employer engagement with HE, this partnership can be viewed as an agent that facilitates the cooperation with firms, especially medium and small enterprises [51].

This program was officially launched in 2013 and was initially focused primarily on VET provision as key to boosting employability and addressing the persistent skill shortages experienced by firms in the regional ecosystem. Over time, it has diversified both its scope of action and the stakeholders engaged in it. The collaboration with local HE is thus more recent and targets joint R&D projects conducted by firms as well as initiatives to reduce skill shortages and gaps.

3. Methods and Data

The data were gathered in the course of an ongoing project undertaken in Portugal to analyze and reflect on employers' engagement with HEIs as a possible avenue for the reduction of persistent skill mismatches at the graduate level. The paper draws on primary qualitative data gathered from face-to-face semi-structured interviews with human resource managers and owners of 19 industry-based firms located in the northern region of Portugal (county of V.N. de Famalicão). The interviews were conducted by two members of the research team, lasted between 1 and 2 h and were fully transcribed. The questions were intended to draw data on (i) recruitment strategies; (ii) perceptions on the preparation of graduates for the world of work and skill problems faced by these firms; (iii) solutions for skill problems (among which training and recruitment policies, relations established with schools and HE and barriers and facilitators to the engagement with these training organizations); and (iv) characterization data of these firms.

This qualitative material was examined through content analysis in order to gain a better understanding of the actual engagement activities developed by local firms with HEIs and the major obstacles and facilitators of those relations. Following the literature review and content analysis of the interviews, we defined several categories for each analytical dimension: skill problems (shortage and gaps); engagement activities regarding the acquisition, training, and assessment of skills, as well as R&D activities; barriers to that engagement, namely cultural/organizational barriers, and facilitators related to personal/social, geographical proximity. A single table containing the selected analytical dimensions was then produced and all the relevant excerpts from the interviews were coded into those categories. This has allowed a more systematic and comparable overview of the analytical data from the interviews. Smaller excerpts were selected for use throughout the paper to illustrate the employers' perceptions of the subjects under analysis.

The firms were selected by convenience sampling and the sample is therefore not statistically representative. However, we have included firms from the most representative sectors (namely textiles, metallurgy, and agri-food) of this strongly industry-based region, with different characteristics in terms of size and years of activity (Table 1). However, the sample is somewhat skewed in relation to size as it includes a higher proportion of large firms than is present in the region which, as noted, is comprised largely of small and medium firms. Most of the firms in the sample have been actively recruiting graduates in

the past three years, notably in different engineering fields, ICT professionals, and, in some cases, also from management and product design areas.

Table 1. Characterization of firms.

Firm	Year of Establishment	Number of Employees	Industry (NACE)
1	1961	753	10.1—Processing and preserving of meat and production of meat products
2	1943	230	10.7—Manufacture of bakery and farinaceous products
3	1937	1216	13.2—Weaving of textiles
4	1927	1131	13.3—Finishing of textiles
5	2011	38	13.3—Finishing of textiles
6	1950	200	13.9—Manufacture of other textiles
7	1970	140	13.9—Manufacture of other textiles
8	2008	50	14.1—Manufacture of wearing apparel, except fur apparel
9	1995	160	14.3—Manufacture of knitted and crocheted apparel
10	1996	146	17.2—Manufacture of articles of paper and paperboard
11	1993	2154	22.1—Manufacture of rubber products
12	1993	63	22.2—Manufacture of plastic products
13	2003	30	22.2—Manufacture of plastic products
14	1981	67	25.9—Manufacture of other fabricated metal products
15	1973	656	26.7—Manufacture of optical instruments and photographic equipment
16	2007	1500	28.1—Manufacture of general-purpose machinery
17	1988	2672	29.3—Manufacture of parts and accessories for motor vehicles
18	2013	308	30.1—Building of ships and boats
19	1999	72	33.1—Repair of fabricated metal products, machinery and equipment

4. Results

This section will start with a brief overview of the main skill shortages and gaps faced by employers in this regional setting. As employers' engagement with HE does not take place in a vacuum, the forms and intensity of these activities are likely to be influenced by either the skill problems at the graduate level or the perceived costs and benefits associated with that collaboration. We will therefore delve deeper into the actual engagement activities developed with HE before examining the perceived barriers and facilitators to that engagement in the next section.

4.1. Employers Engagement with HE at the Regional Level

Skill problems include skill shortages, translated into hard-to-fill vacancies, and skill deficits or gaps which relate to the employers' perceptions of graduates' level of preparation for the world-of-work. These gaps were further typified under the categories of soft skills, work attitudes/maturity, and technical skills.

Regarding skill shortages and hard-to-fill vacancies, a non-negligible proportion of the employers (8 of 19) refer to difficulties in finding and retaining graduate employees in the region, giving rise to constraints in their activity. Most of these vacancies are found in technical areas such as Engineering (F6; F15; F18; F1; F11), ICT (F6; F10; F12), and Physics (F15). Three sets of factors are reported by the sampled employers to explain skill shortages. First, they blame HEIs for a skill shortage that causes an undersupply of graduates in these areas, despite the massification of HE. Second, the good labor market conditions, notably low level of unemployment and the greater bargaining power of graduates, which increase the labor costs: "*it's a region of full employment [. . .] in all areas of expertise it is now very difficult and it's the candidates who choose where they want to go and what they want to do*." (F16); "*I would say in engineering nowadays you are only unemployed if you choose to be (. . .) people are much more selective today*" (F15). Finally, the brain drain of young qualified people is a problem that affects the sampled firms. The demand for talented youngsters from large neighboring cities and the international labor market makes it more difficult for employers from the relatively small town where these firms are based to attract and retain a skilled workforce.

In terms of graduates' preparation for the world-of-work, there is widespread consensus that HE graduates are well endowed with technical skills, "*technical skills are excellent*"

(F8), and "*nowadays students have a far higher skill level than when I finished university*" (F6). However, employers claim graduates are poorly prepared in soft skills and work attitudes (12/19). They report graduates often lack soft skills such as written and oral communication, problem-solving, and transversal skills in general: "*In terms of technical skills, they are better prepared but what they lack is some behavioral and social skills*" (F6); "*I feel that teamwork is an issue as is communication; the ability to communicate both orally and in writing is definitely a problem*". (F13); "*Nowadays, we give as much value to behavioral skills as we do to technical skills, something which did not happen a few years ago*" (F3).

The work attitudes, commitment, and behavioral skills of recent graduates are a major concern (15/19). These characteristics are highly valued by the firms and are widely regarded as instrumental for the use of other technical skills to the benefit of the organization (F4; F11; F3, F2). Thus, HEIs are often blamed for not sufficiently addressing soft skills and attitudes, alongside the technical skills (F6; F1): "*They [graduates] have difficulties in interaction and communication (. . .) but I don't see the universities addressing this issue of soft skills*" (F1).

The next question is the employers' willingness and/or ability to engage with HE to tackle skill problems. Table 2 displays the engagement activities of the sampled employers, as well as the barriers and facilitators of this engagement. As can be seen, HEIs serve as a recruitment channel to access the best candidates and engage in the training of graduates through internships. All firms develop at least one of these types of interaction and a non-negligible number (9/19) engages in three. Firms sometimes also participate in job fairs and events at the university (F16; F5).

Table 2. Firms' engagement activities with HE and barriers/facilitators to engagement.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Engagement with HE																			
Search for good candidates	x		x	x		x		x	x		x	x	x		x	x	x	x	
Information on candidates	x		x	x		x		x			x				x	x			
Internships for students	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x
Assessment of students															x				
Accreditation of training																			
Teaching at HE																			
Course co-design																			
Participation in governance																			x
Collaboration in R&D	x	x	x	x	x		x		x			x							
Barriers																			
Cultural/organizational barriers	x	x		x		x	x	x			x		x			x			
Facilitators																			
Social/interpersonal proximity			x			x					x	x			x	x			x
Geographic proximity	x		x	x		x	x		x	x		x			x	x			

The internship programs are regarded as an opportunity to provide some real-world training to students while allowing for candidates to be screened to create a pool of talent. The internships target both graduates (masters and PhD) and non-graduates and occur throughout the year or in the summer. Internships also result sometimes from students visiting the firm (F16). F4 regrets that some students have never had any contact with an organization and, consequently, are unaware of the world of work. These internship programs are often implemented through formal agreements between firms and HEIs and are reported as beneficial by the sampled employers:

> "*That has been the way recently, we establish protocols with the universities in the region to receive interns and then recruitment comes from those visits (. . .) the truth is that they are very receptive to what we have to say just as we are very receptive to what they have to show us.*" (F16);
>
> "*Yes, we work with different internship programs and we have our own program too. We like to receive those interns, especially because in nine months or so they will enter the labor market. And if we can have this contact before and the student can also get to know the reality of a company, it can facilitate their choice afterwards*" (F1);
>
> "*We have some people coming here for internships. Some come to do their Master thesis. They usually have to face a problem and then come up with a solution. (. . .) It is good, it is a way of evaluating people and knowing if they are good enough to stay.*" (F18).

Activities such as teaching, collaboration in course design, or participating in HE governance bodies are scarcely reported by employers. However, they intend to engage more actively in these activities and some firms, namely medium and larger firms, are sometimes invited for this kind of collaboration. In such cases, these types of firm are consulted in the design and demanded an assessment of the course: "*Well, I know that one of our engineers here participates in one of these [governance] bodies (. . .) sometimes they ask to use some of our machines, they have visits here or we donate some equipment. I know they sometimes discuss some new degrees, pedagogic content, what makes more sense or not*" (F19). Nevertheless, employers call on the expertise of HE institutions if they are unable to properly prepare graduates: "*We have people with a lot of know-how that want to pass on that knowledge [to graduates] but they don't know how to do it (. . .) so what we did was a partnership with the . . . Business School*" (F17).

However, this is a random activity, often resulting from the employers' interpersonal relations with HE professionals, so it is far from a systematic and internalized process. Overall, the sampled employers indicate that there is room to deepen the engagement and they are willing to do so. Nevertheless, as we will see later, there are barriers that hamper closer ties.

The collaboration in R&D activities attracts wide attention and prevails in 8/19 firms. It should be noted that the firms in the sample are industry-based and need to develop new products and technologies, which entails close interaction with HEIs. At the same time, firms and HEIs have strong incentives and a long history of cooperation in R&D: "*Nowadays we have two R&D projects in cooperation as well as several in the 2020 [program] in the areas of innovation and markets, especially because we have opened up to cooperation with universities. Beforehand secrecy was the soul of business but not anymore . . . "* (F7). "*In R&D we have seven people, three of whom are doctorates (. . .) we will always have to resort to research centers because they have other skills that we don't have.*" (F3). The engagement not only involves R&D but also post-graduate training and sometimes the recruitment of master or PhD graduates that participate in the development of products and technologies. A sectoral pattern emerges in the collaboration with HE in R&D in that firms from the agri-food and textile sectors seem to be more engaged in collaborative R&D than those from other sectors, namely metallurgy, machinery, and components for the automobile industry. One possible explanation is that the textile industry in the region has undergone a strong technological upgrade in recent decades that has been widely recognized, and therefore resorts more to this sort of collaboration. However, these results should be treated with caution because other industries, namely those related to the automobile industry, may be more prone to producing in-house R&D (or in collaboration with other firms in the sector).

In sum, the reported engagement activities show that employers are aware of the relevance of HEIs as skill suppliers and often contact them to acquire talented people. However, they are still far from participating systematically in the skill formation process, although some are trying to do so. As noted, the sampled employers are available and intend to extend their engagement, so it should be possible to make progress in the future. Currently, R&D continues to be the major activity of contact between employers and HEIs.

4.2. Barriers and Facilitators to Employers' Engagement with HE

The sampled employers reported a set of barriers and facilitators of engagement. More specifically, cultural differences that prevent fruitful communication between HEIs and firms are perceived as the major issue. HEIs are generally accused of being distant from firms (F16; F6; F8; F7; F18; F4; F11, F2) and from the world-of-work. "*The world is moving at one pace and universities are another*" (F6); "*I believe the universities are still distant (. . .) the students should be put in contact with firms sooner in their university trajectory as they are in programs abroad where the connections with firms start in the first year of college*" (F8). HEIs continue to be focused on academic activities and disregard the requirements of employers. According to these employers, it is the HEIs that fail in setting shared goals and a common language that would increase proximity and develop ties: "*We need a stronger connection with reality (. . .) and that does not happen. It does not happen on either side because firms try to get closer and then often lose their patience because of bureaucracies (. . .) and universities often use firms just for statistics so that they can say they have links with firms and present those numbers*" (F2). This detachment exacerbates the mismatch between the skills acquired at HE and those required by employers (F8; F18; F11; F2). Two employers (F3; F11) highlighted their willingness to collaborate with vocational schools. They noted the benefits of working with vocational training institutions rather than with universities or polytechnics, notably the flexibility to adapt the curriculum and pedagogical methods, and teachers' knowledge of skill requirements that help a better match of the skill supply.

Some employers recognize that some steps have been taken in recent years to overcome organizational barriers (F16; F15; F18; F19), and some HEIs try to be more responsive to firms' needs and engage more actively with them. However, for these firms, HEIs have not yet provided an adequate response to employers' apparent willingness to engage more actively with HE, and the costs of these engagement activities incurred by firms still exceed the potential benefits: "*The relations have improved, I'm not going to say they haven't, but they still need to be closer*" (F16); "*I believe relations are increasingly better and I see HEIs making strides to come and ask the firms, something which didn't happen before (. . .)* [HEIs] *are proactively trying to get closer to firms*" (F15); However, the trade-off between costs and benefits is at the heart of the discussion. "*We must also see what is the economic benefit for us (. . .) generally the end result is more of a burden and a loss for our activity*" (F19). Employers suggest engagement is a risky activity that has uncertain benefits.

The barriers are not limited to HEIs with some firms (F11; F2) referring that they refrain from establishing closer links to HE. Others acknowledge that their willingness to engage is often lessened by the above-mentioned barriers and they must take initiatives to improve the ties with HE. Faced with the trade-off between costs and benefits, the sampled employers propose solutions to increase effective engagement.

The sampled employers enumerate some facilitators: They believe that personal contacts, notably through alumni and teachers, are efficient ways of finding appropriate partners inside the HEIs and conducting research projects and/or finding talented candidates: "*We are not approached. Fortunately, we have a relationship (. . .) with universities and polytechnics, with teachers and alumni that allows us to implement our normal* [hiring] *processes. What we feel is that without these actions we would not be contacted either by universities or polytechnics*" (F11). However, F3 reports that "*Our relations with HEIs happen in two ways: either we proactively contact them because we have a specific need and then relations are established, or there is someone here at the firm that has a good relationship with someone at the university and then the collaboration follows through that different channel*." In other words, personal contacts appear to be a facilitator for closer ties between HEIs and the world of work.

Geographical proximity is an additional facilitator reported by the sampled employers. Regional universities easily create networks with local employers since they have a deeper knowledge of the region and employers' needs. Consequently, employers refer to local interactions rather than national and distant partners (F16; F6; F15; F7; F10; F1; F12; F3). On the one hand, geographical proximity eases face-to-face interactions and access to information about institutions and people able and willing to establish partnerships. On

the other hand, it helps create a pool of talents of young graduates in HEIs closer to their homes and searching for job opportunities in the local or regional labor market. Some employers speak about these advantages:

> "*We work a lot with the [local] University (..) we give priority to the [local] University because of a partnership we established several years ago, because of geographic proximity (. . .) we have a lot of people here from that university. We have a good relationship with the presidency and the vice-presidency and great proximity also with the school of engineering" (F15). "We work with several institutions on account of proximity*, [local] *University, the Polytechnic* . . . [all in the Northern region of Portugal]" (F1). However, in addition to fruitful experiences, some underline the specificity of education programs and technological specificities of certain HEIs (F13; F18). Others are "*available to collaborate with any HEI as long as the attitude is appropriate*" (F4; F7; F8)

We now turn to the relationship between engagement activities and the barriers or facilitators reported by the sampled employers. One group is made up of firms that use HEIs as a recruitment channel but acknowledge that cultural barriers probably prevent other types of engagement (F8, F1, F2). Others follow the same strategy but take advantage of personal contacts and geographical proximity to overcome such barriers (F16, F6); use only of the proximity to overcome them (F7, F1, F4); or use only interpersonal contacts (F11). In other words, barriers are compensated by some facilitators, especially to allow firms to access talented graduates.

It is interesting to note that F19 is actively engaged with HEI and this was facilitated by personal contacts; however, he/she refers to skill shortages and admits that young graduates lack work attitudes and maturity. Furthermore, firms must also tackle cultural barriers to develop collaboration in R&D. This is given as the major factor inhibiting stronger university-business collaboration.

Finally, regarding the role of Famalicão Made IN, the local partnership, many employers recognize that it has already positively impacted R&D collaboration between HE and firms, access to funding, the visibility of firms, and the county and it has facilitated access to other local and national institutions and decision-makers. Some of the R&D partnerships and engagement activities have indeed resulted from post-graduate training work and knowledge interactions, and the county is currently trying to expand these projects. However, most employers are also aware that much work is required to address local skill problems and, more importantly, to align the supply of and demand for higher-level skills, as well as to overcome existing barriers between firms and HEIs. It should be noted that Famalicão Made IN has very recently taken steps to work with HE, and it can become an efficient broker to reduce cultural barriers in the future.

5. Discussion and Conclusions

This research contributes to our understanding of two key but often neglected questions in the literature: Are employers willing and able to actively engage with HEIs to become a viable solution for skill problems at the graduate level? What are the main barriers and facilitators of the engagement activities with HE experienced by firms?

Our results show that the sampled employers use HEIs as a recruitment channel and set aside active forms of engagement that would allow them to directly influence the supply of skills. These results are in line with the relatively sparse and fragmented literature on employer engagement with HE in education and training in Portugal, for example, [28,34,48]. However, despite the sampled employers' willingness to develop more active forms of engagement, some barriers remain.

Given the data displayed in Table 2, the efficiency of engagement activities must be questioned. We note that F19 laments skill shortages and a lack of graduates despite being engaged in active strategies. These examples confirm that there is no one-size-fits-all solution for skill problems [28]. Active engagement, through shared governance, for example, does not seem to be the answer either.

When examining the employers' perception of the barriers and facilitators of engagement, we found that a cultural mismatch between business strategy and academic language is the major barrier [19]. HE and the sampled firms seem unable to fully communicate through a common language and goals. This probably prevents active engagement and two employers (F3; F11) expressed their preference for vocational education institutions that show greater flexibility and responsiveness than HE. These firms noted structural barriers related to the strategy of the curriculum and pedagogical methods [18] that differentiate HE from other levels of education.

This raises the question of whether HE should change its goals and language so that it can cooperate closely with the world of work? Previous research has shown that the expectations of employers vary, for example, [28] with some employers preferring to hire ready-to-work candidates provided by HEIs, while others deliver training and ensure that newly hired workers are endowed with specific skills. In fact, the training policies of the employers in our sample involved preparing their workforce and using internships as the key to screening and training graduates.

Turning to the facilitators of engagement, the sampled employers emphasized the role of trust in developing sustainable collaboration. Some know which institutions have responses to their technical skills requirements [30]. Although HEIs' proactive approach to employers was noted [33], all employers are also aware of the costs of engagement [10] and acknowledged the trade-off between costs and benefits [13]. This leads us to the discussion of public investment in the engagement activities [36]. We agree that it involves multiple sources [37] and the stakeholders involved must acknowledge the relevance and the economic and social impacts of investing in engagement. Public intervention would probably be translated into regulations that guarantee equity among different types of HEI and different types of employers. The reform of Portuguese HE in 2007 strived to engage external stakeholders at non-executive governance bodies of HEIs. However, to date, their participation is still minimal to non-existent and is sometimes referred to as imaginary or non-interfering friends [52].

Our study found that the sampled employers reported geographical proximity as well as personal and social contacts; this later appeared as a major factor for successful cooperation. It is the alumni that sometimes open the door to HEIs and support collaboration [34]. So, when the sampled employers had suitable partners [15], they were able to access talented graduates. The multi-stakeholder partnership was also seen as a broker to help build bridges between HE and employers [25].

Geographical proximity interacts with this [13] as informal relations in a small region seem to be the perfect recipe for encouraging collaboration and communication. Finally, while the multi-stakeholder partnership attempts to build bridges between HE and the market [51], employers acknowledged that further work is required to improve the partnership's role as a broker to ease cooperation.

The reported facilitators raise trust which may encourage employers to become stakeholders that can help foster graduates' employability and create opportunities for the world of work to be embedded in HE. However, the development of employability skills is a shared responsibility [28] and HE has to fulfill multiple missions and respond to economic as well as social and cultural needs.

Although the findings achieved thus far are interesting, they should be interpreted with caution. This is a case study of one region using a sample of firms solely from industry sectors. Future research should therefore explore the skill problems of other sectors and preferably of other regions. This might be useful to ascertain the national and regional level differences of skill problems, as well as the solutions and the barriers/facilitators to tackle them. Policymakers, HEIs, and employers should understand that multiple solutions are required to reduce skill mismatch, shortages, and gaps, and all stakeholders are responsible for finding appropriate answers. However, each stakeholder has its own culture and language, and efforts should be taken to improve communication and interaction between them.

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Teaching Sentiment in Emergency Online Learning—A Conceptual Model

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Abstract: Due to the COVID-19 pandemic, higher education institutions with a face-to-face model have found themselves in the contingency of migrating to online learning. This study explores the perspective of all the lecturers at a Portuguese private higher education institution who were invited to participate, regardless of their research area, in this questionnaire. It aims to propose and test a conceptual model that combines attitudes, preferred activities, and technological experience with the sentiment about the impact of this experience on students' learning process, on their teaching activity, and on the strategy of higher education institutions. An online questionnaire was conducted to 65 lecturers engaging in emergency online lecturing. The obtained results showed that lecturers reveal a positive attitude towards online lecturing, tend to prefer activities in which they feel most comfortable in face-to-face lecturing, and consider having technological experience useful for online activities. Lecturers have a positive sentiment about the impact of online learning on students' learning, their faculty career, and the strategy of higher education institutions. The proposed conceptual model test shows that the model has well-fitting conditions. The results confirm the hypotheses formulated: namely, the predictive effect of attitude, preferred activities, and technological experience on sentiment. Faculty engagement in emergency online lecturing shows that the members are available to participate in the changing process, and the proposed conceptual model can be used to assess this readiness.

Keywords: COVID-19; emergency online learning; emergency online teaching; higher education; lecturers; online learning; Portugal; sentiment analysis

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1. Introduction

The COVID-19 pandemic has affected higher education institutions (HEIs) in their activities in order to promote the protection of their lecturers, staff, and students in a public health emergency. The institutions had no alternative but to cancel all face-to-face lectures, including labs and other learning experiences, and to determine that lecturers completely switch the courses to emergency online learning, reducing contacts and thereby preventing the spread of the virus.

This teaching model that many call "emergency remote teaching" [1], includes the use of totally remote teaching solutions, mediated by the internet, to ensure activities that would otherwise be taught in a face-to-face form, returning to this format once the crisis or emergency is overcome [1]. The followed model seems similar to the online learning that has been stated by Anderson [2], referring to a teaching and learning type in which: (1) the student and the lecturer are at physical distance; (2) student–content, student–lecturer and student–student interactions are mediated by technology; and (3) some type of support is provided [2].

In the COVID-19 context, higher education lecturers were challenged by the need for the adoption of online learning practices, for which the majority were not prepared [3], and

there were no indications that they were interested in using it [4]. The faculty members had to prepare and teach their lectures from home, with all the practical and technical challenges that this entails, and often without adequate technical support [1]. In addition to the lack of required online specific pedagogical competences, it is generally agreed that in a normal situation, the challenge to effectively transfer what is taught in a face-to-face classroom to an online version remains a problem [3]. Most of these lecturers, who normally develop their activities face-to-face, do not reveal an interest in online learning (only about 30% to 35% consider this option) [4,5]. This position is caused by the lack of motivation and incentives resulting from various obstacles that can be summarized as technological readiness [6–8], absence of organizational incentive to compensate for extra work [9,10], and the prejudices related to the value of online teaching [5,11,12].

In a normal situation, the most relevant motivations for adopting online learning are related to the concern of reaching new audiences, diversifying the HEI's offer, and contributing to the management of organizational change and the positioning of the HEI´s offer in the context of online education [9,11–13].

In the emergency caused by COVID-19, lecturers needed, overnight, to use tools with which they felt comfortable [14]. Face-to-face lecturers thus needed to develop online teaching activities in order to avoid the collapse of the teaching and learning process. In this situation, lecturers adopted emergency remote teaching that. as stated by Hodges [1] (p. 6), "is a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances". Emergency online teaching is different from all other situations in which online teaching and learning activities are planned by lecturers who have online teaching skills. For many of these lecturers with little or no experience in online teaching, the option was to transport the typical activities they developed for face-to-face teaching to the online environment and, gradually, introduce activities that would allow more meaningful learning [15]. Despite the skills and support limitations, lecturers have a positive sentiment about emergency online learning [16,17].

The present investigation focuses on the motivations of lecturers with no, or little, experience in online teaching. Without any other option, these lecturers were required to adopt emergency online teaching. In order to address this great challenge, lecturers changed their attitude towards online education, their favorite activities, and technological experience. This study aims to investigate whether these feelings and skills affect online teaching sentiment. It aims to understand how lecturers perceive the impact of this experience on students' learning, on their teaching activity, and in the development of HEI online learning strategy.

The document is organized into six sections: the present section, which introduces the research topic, the motivation, and the aim; the following section, which presents the conceptual model and hypothesis for the research; the methodology is then described, followed by the sections of the obtained results, its discussion, and final remarks in the conclusions.

2. Conceptual Model and Hypotheses

From the existing literature, several theories and models have emerged that have in common the objective of explaining the intention to use technologies through the relationship between latent, including external and outcome, variables [18,19] Although these models have been developed with the aim of explaining and predicting the acceptance of computer technologies in general, they have been adapted with a view for their application in more specific contexts, such as online teaching and learning [20,21].

Contrary to previous studies, this study is based on the migration from face-to-face to emergency online education. It was carried out without the lecturers involved having had any opportunity to carry out any type of training, and these had only minimal support. They were limited to providing access to the platforms and technologies used. For this study, a conceptual model is proposed that combines factors that can be measured when face-to-face lecturers have transferred their activities to emergency online learning, namely:

(1) online teaching attitude (OTA); (2) preferred online activities (POA); (3) technological experience (TEX); and (4) online teaching sentiment (OTS).

2.1. Online Teaching Attitude (OTA)

The attitude towards online teaching and learning is identical to that shown in other pre-pandemic studies [18–21]. It consists of appraising individuals' positive or negative feelings (evaluative affect) about the use of online education [9,18,19]. The following two hypotheses are proposed:

Hypothesis 1 (H1). *OTA positively affects OTS.*

Hypothesis 2 (H2). *OTA positively affects POA.*

2.2. Preferred Online Activities (POA)

The activities proposed by lecturers in emergency online learning, with which most did not have previous experience, ended up following those recommended in the existing literature. They choose to diversify the activities and the materials used, thus seeking to correspond to the different student learning profiles [22,23]. The activities preferred by lecturers when migrating activities to emergency online teaching can be compared with the concept of self-efficacy. According Jo et al. [24] (p. 50), "self-efficacy reports to lecturers' personal beliefs about their abilities and skills". It seems normal that lecturers prefer the activities in which they feel more qualified and competent. Thus, Hypothesis 3 (H3) is suggested: POA positively affects OTS.

2.3. Technological Experience (TEX)

Technological experience identifies the degree of technological readiness [25] of the lecturers from their perspective [26]. As mentioned by Abdullah and Ward [27], experience plays an important role in the adoption of online education and can be defined as "the amount and type of computer skills acquired by a person over time" [27] (p. 34). For Joo et al. [24], "it is important for lecturers to have enough time and opportunities to practice new technologies until they feel comfortable enough to use the technology and perceive that technology". In a context in which lecturers did not have that time, technological experience seems to be an important factor that can influence online teaching sentiment [28]. The following three hypotheses are proposed:

Hypothesis 4 (H4). *TEX positively affects OTS.*

Hypothesis 5 (H5). *TEX positively affects OTA.*

Hypothesis 6 (H6). *TEX positively affects POA.*

2.4. Online Teaching Sentiment (OTS)

According to Liu [29] (p.15), "sentiment is the underlying feeling, attitude, evaluation, or emotion associated with an opinion", which is represented by three aspects: the type, orientation, and intensity of the sentiment. In the context of this work, the lexicon-based approach that involves calculating the orientation of feeling from the semantic orientation of words or phrases was used. The orientation of the sentiment can be positive, neutral, or negative. Neutral means the absence of sentiment or no sentiment or opinion [29,30]. Sentiment intensity is an important aspect for the classification of the feeling associated with a sentence [31]. For example, "good is weaker than excellent, and dislike is weaker than detest" [29] (p. 16).

Sentiment analysis is studied in many different contexts, with machine learning and natural language processing being the most common techniques [32]. In the current research, sentiment analysis was based on processing natural language and extracting information that examine phrases and assign to each one of them a sentiment polarity

(positive, negative, neutral) [29,33]. By this way, the opinions expressed by lecturers in relation to the impact of the online emergency teaching was assessed in three aspects: (1) impact on students' learning; (2) impact on their future teaching activity; (3) impact on the future HEI online learning strategy.

Based on the previous theoretical variables, the conceptual model with the relationships between all the factors that influence OTS is presented in Figure 1.

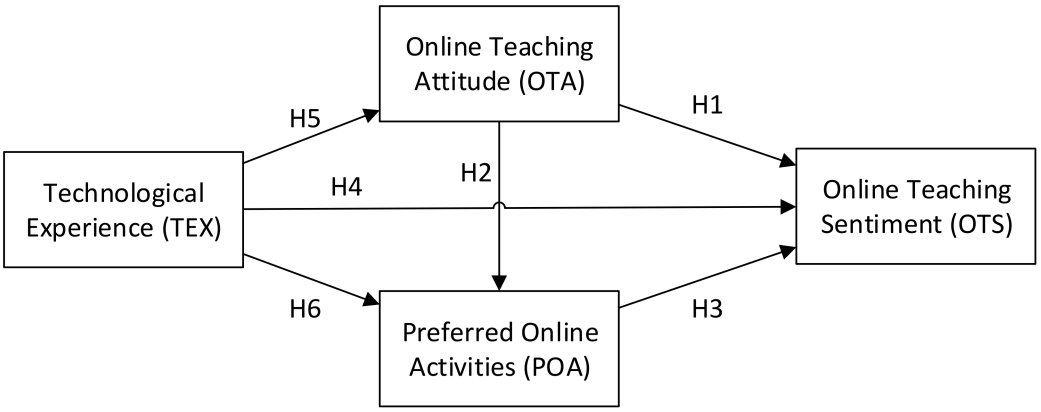

Figure 1. Conceptual model.

3. Methodology

3.1. Participants

The participants (n = 65) were lecturers form a Portuguese private HEI. This HEI has a total of 98 lecturers that were invited to participate in the questionnaire. The link to questionnaire was sent to everyone through e-mail message, along with an introduction about the research objectives.

3.2. Data Colletion

The data were collected through online surveys from April to May 2020. The aggregated response rate was 79%, and the final sample consisted of 66% of the reference population. From 98 potential respondents, 78 questionnaires were answered by respondents, of which 13 were rejected because of missing values.

3.3. Lecturers' Personal Information/Demographic Data

In the total of sample of lecturers, the percentage of females was 40%, while that of males was 60%. A total of 1.5% of lecturers were up to 29 years of age, 13.8% from 30 to 39 years of age, 46.2% between 40 to 49 years of age, 21.5% between 50 to 59 years of age, and 16.9% were 60 years of age or older. In terms of the academic qualifications of the lecturers, 23.1% of participants held bachelor's degrees, 33.8% held master's degrees, and 43.1% held a doctoral degree. The teaching experience shows that 18.5% had up to 4 years, 20% had from 5 to 9 years, 24.6% had 10 to 19 years of experience, and 36.9% disclosed 20 or more years of experience.

3.4. Survey Instrument and Structure

The questionnaire consisted of six sections. The first section intended to characterize the respondents. In the second section, respondents were asked about their attitude toward online teaching and learning with a 5-point Likert scale (1—lower; 2—sometimes lower; 3—no significant differences; 4—sometimes higher; 5—higher). The third section was to evaluate the degree of preference/satisfaction with the online activities. A 10-point end defined scale with ratings from null (1) to high (10) was chosen, in order to produce increased sensitivity of the measurement instrument [34]. In the fourth section, respondents were asked to self-assess their technology skills. A 4-point Likert scale was adopted (1—none; 2—up to 3 years; 3—from 3 to 6 years; 4—more than 6 years).

The fifth section of the questionnaire survey presents three open questions about the impact of emergency online teaching and learning in the present and in the future of (1) student´s learning, (2) teaching activities, and (3) online learning and teaching in HEI strategy. These questions are intended to collect data for sentiment analysis about online learning and teaching. Table 1 presents the constructs of each section and the sources which inspired them.

Table 1. Constructs and their inspiration sources.

Section	Constructs	Number of Items	Source
2	Online teaching attitude (OTA)	3	[18,19]
3	Preference online activities (POA)	5	[35,36]
4	Technological experience (TEX)	3	[25,26,37]
5	Online teaching sentiment (OTS)	3 (*)	[38,39]

(*) Open questions.

3.5. Pilot Study for the Questionnaire

A pilot study was conducted to check the reliability of the questionnaire items. The sample size was set based on 20% of the aggregated sample size of this study (98 lecturers) and thus adhered strictly to the research criteria. Cronbach's alpha test was utilized for the computation of internal reliability [40] through IBM SPSS Statistics v26, in order to judge the outcomes of the pilot study. A value of 0.7 was taken to be an acceptable value for the reliability coefficient, considering the model for social science research [41–43]. The appropriate findings are shown in Table 2.

Table 2. Cronbach´s alpha value for pilot study.

Alfa de Cronbach	Number of Items
0.792	11

3.6. Sentiment Analysis

The fifth section of the questionnaire presents three open questions about the impact of emergency online teaching and learning in the future of (1) student´s learning, (2) teaching activities, and (3) online learning and teaching in HEI strategy. These questions are intended to collect data for sentiment analysis towards online learning and teaching.

There are many applications and enhancements on sentiment analysis algorithms that have been proposed in the last few years [33]. For this work the OpLexicon 3.0 was used. It is a sentiment lexicon for the Portuguese language, built using multiple sources of information, and has four categories of words: verbs, adjectives, hashtag, and emoticons. The lexicon is constituted of around 32,000 polarized words classified by their morphological category and annotated with positive (1), negative (-1), and neutral (0) polarities [30,38].

The sentiment analysis was developed in R [44] following the following steps represented in Figure 2: (1) the words are extracted from each answer of the open questions in the questionnaire; (2) verification of whether the word is present in the OpLexicon and determination of the polarity; (3) the sum of the polarity of the word in the answer is determined; and the final step is (4) to convert the sum of polarity to a Likert scale.

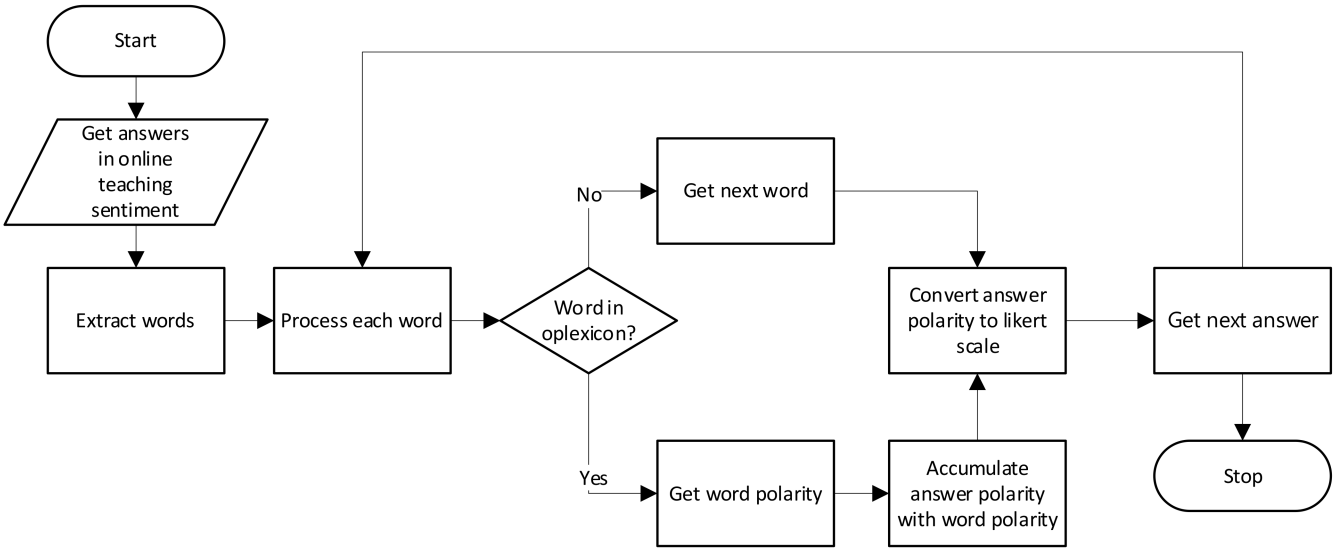

Figure 2. Flow-chart representing the determination of the polarity of the open questions.

The conversion to a Likert scale was based in the following Algorithm 1, where each answer is processed after the determination of the cut points (median values) used to convert to a scale aligned with the other questions of the survey:

Algorithm 1 Likert Calculation

```
Input: polarity of the open questions
Output: likert values for open questions
Begin: likertCalculation
assign median(negative answer polarity) to mNegSent
assign median(positive answer polarity) to mPosSent
assign 0 to answerPolarity
for each answer do
if answerPolarity <= mNegSent then
        answerLikertScale = 1
else if answerPolarity > mNegSent and answerPolarity < 0
        answerLikertScale = 2
else if answerPolarity = 0
        answerLikertScale = 3
else if answerPolarity <= mPosSent and answerPolarity > 0
        answerLikertScale = 4
else if answerPolarity > mPosSent and answerPolarity > 0
        answerLikertScale = 5
End: likertCalculation
```

As an example, considering the opinion "I consider that my adaptation was made in a smooth way", the next step is the processing of each word: "I (1) consider (2) that (3) my (4) adaptation (5) was (6) made (7) in (8) a (9) smooth (10) way (11)". To determine the polarity of each word, OpLexicon 3.0 was used. In the example given, only the word "smooth" (10) returns value 1 (positive polarity) from OpLexicon; all the other words do not have an associated polarity, returning "word is not present in dataset". The algebraic sum of the returned values is 1. Consequently, this answer would get a polarity value of 1. After performing this step, an algorithm is developed following the "Likert calculation", calculating the median of the negative and positive words in each question: (1) negative values less or equal to the negative values median were assigned one, (2) negative values less than zero and greater than median were assigned two, (3) 0 (neutral) was assigned three, (4) positive values and less than positive median were assigned four, and positive

values greater than positive mean wrtr assigned five. The null values were replaced by 0 representing the absence of an answer.

3.7. SPSS and SmartPLS 3

The demographic data was evaluated with the aid of IBM SPSS Statistics v26. SmartPLS 3 software was used with a graphical user-interface to estimate the PLS-SEM models [45]. This tool can cope with smaller sample size (<100), non-normal data, exploratory research for the same effect size and model complexity, and it can more easily specify formative constructs [46,47].

3.8. Adjustment Quality for the SEM Model

The following fit measures were considered to assess the adjustment quality of the model:

- Loadings. For a well-fitting model, path loadings should be above 0.70 and "indicator with a measurement loading in the 0.40 to 0.70 range should be dropped if dropping it improves composite reliability" [46] (p. 103). Having tested this option, the conditions were not met, and the items were not dropped.
- Variance inflation factor (VIF). Indicates multicollinearity. In a well-fitting model, the structural VIF coefficients should not be higher than 5 [48].
- Cronbach Alpha (CA). George and Mallery [49] suggest the following scale: >0.90 "Excellent", >0.80 "Good", 0.70 "Acceptable", >0.60 "Questionable", >0.50 "Poor" and <0.50 "Unacceptable".
- Composite reliability (CR). Values between 0.70 and 0.90 are considered satisfactory [46].
- R-square. Results above the cut-offs 0.67, 0.33, and 0.19 to be "substantial", "moderate", and "weak", respectively [46].
- Average variance extracted (AVE). Greater than 0.50 means that the model converges with a satisfactory result (AVE > 0.50) [50].
- Discriminant validity (DV). The square roots of the AVEs should be greater than the correlations of the constructs [51].
- F-square. Values of 0.02 represents a "small" effect, 0.15 represents a "medium" effect, and 0.35 represents a "high" effect size [46].

The values presented in Tables 3–5 show that the model has well-fitting conditions.

Table 3. Adjustment quality for the Structural Equation Modeling SEM model.

Constructs	Items	Loadings	VIF	CA	CR	R-Square	AVE
OTA	OTA1	0.885	1.950	0.840	0.902	0.026	0.755
	OTA2	0.900	2.238				
	OTA3	0.819	1.867				
POA	POA1	0.609	1.759	0.802	0.848	0.300	0.557
	POA2	0.891	2.663				
	POA3	0.834	1.933				
	POA4	0.718	1.586				
	POA5	0.642	1.622				
TEX	TEX1	0.768	1.303	0.686	0.687	–	0.615
	TEX2	0.753	1.317				
	TEX3	0.830	1.531				
OTS	OTS1	0.772	1.580	0.789	0.821	0.155	0.699
	OTS2	0.866	1.879				
	OTS3	0.867	1.626				

Table 4. Discriminate validity.

	OTA	OTS	POA	TEX
OTA	**0.869**			
OTS	−0.091	**0.836**		
POA	0.160	0.157	**0.747**	
TEX	0.351	−0.211	0.472	**0.784**

Diagonal values (in bold) are Composite reliability (CR).

Table 5. F-square.

	OTA	OTS	POA	TEX
OTA	-	0.030	0.111	-
OTS	-	-	-	-
POA	-	0.126	-	-
TEX	0.026	0.125	0.254	-

Finally, evaluating the predictive validity or Stone–Geisser indicator for the accuracy of the adjusted model. $Q^2 > 0$ implies the model has predictive relevance [46,52] (Table 6).

Table 6. Predictive validity (Q^2).

Constructs	SSO	SSE	$Q^2 = 1 - (SSE/SSO)$
OTA	195.000	195.000	0
OTS	195.000	180.284	0.075
POA	325.000	325.000	0
TEX	195.000	195.000	0

SSO—sum of squares errors using mean for prediction; SSE—sum of squares prediction error.

4. Results

4.1. Online Teaching Attitude

The results showed that respondents have a positive attitude towards online teaching. The item "I have the same availability for online as for face-to-face teaching "(OTA3) has an average of 3.71, while the item "quality of online education in relation to face-to-face education" (OTA1) has 3.25, and the item "I like online education in the same way as face-to-face education" (OTA2) has an average of 3.14 (Table 7).

Table 7. Online teaching attitude.

Item Cod	Item	Means	SD *
OTA3	I have the same availability for online as for face-to-face teaching	3.71	0.85
OTA1	Quality of online education in relation to face-to-face education	3.25	0.98
OTA2	I like online education in the same way as face-to-face education	3.14	1.12

(*) Standard-deviation.

4.2. Preferred Online Activities

Lecturers revealed greater preference for "online sessions" (POA4) with a mean of 8.48, "oral presentations" (POA3) with 7.66, and "written assignments" (POA2) with 7.34 (Table 8).

Table 8. Preferred online activities.

Item Cod	Item	Means	SD *
POA4	Online sessions (Zoom, Teams, etc.)	8.48	1.44
POA3	Oral presentations	7.66	1.85
POA2	Written assignments (in group)	7.34	2.26
POA1	Discussion Forums	6.88	2.09
POA5	Chat Activities	6.48	2.20

(*) Standard-deviation.

4.3. Technological Experience

Respondents showed high experience in the use of "online meeting systems" (TEX1), with an average of 3.94. The remaining items evaluated obtained average values above 3.0 (Table 9).

Table 9. Technological experience.

Item Cod	Item	Means	SD *
TEX1	Online meeting systems (Zoom, Teams, etc.)	3.94	0.24
TEX3	Online learning environments (Moodle, etc.)	3.29	0.84
TEX2	Collaborative work tools (Google Drive, etc.)	3.18	0.91

(*) Standard-deviation.

4.4. Sentiment Analysis

The results of sentiment analysis of the open questions allowed the identification of their sentiment value, as exemplified in Table 10, for impact on lecturers' careers.

Table 10. Example of qualitative sentiment for the impact on lecturer´s careers.

Portuguese (English *)	Sentiment	Likert Value
Enquanto docente, esta foi a minha primeira experiência no ensino à distância. Considero que a minha adaptação se efetuou de uma forma tranquila. De relevar que é necessário adotar abordagens mais exigentes na preparação das aulas. Requer a utilização de formas adicionais para captar a atenção do estudante e de os motivar. Aula após aula a assiduidade melhorou significativamente. (As a lecturer, this was my first experience in distance learning. I believe that my adaptation took place in a calm way. It is important to note that it is necessary to adopt more demanding approaches in class preparation. It requires the use of additional ways to capture the student's attention and motivate him/her. After lecture attendance has improved significantly. *)	5	5
Maior flexibilidade/disponibilidade e novas aprendizagens. Maior preparação para futuras situações ou oportunidades. (Greater flexibility/availability and new learning. Greater preparation for future situations or opportunities.)	1	4
É o mesmo. (It is the same. *)	0	3
O formato de ensino online é mais difícil para o professor do que o formato presencial. A preparação e logística das aulas online é maior do que para presenciais, bem como o tratamento que é necessário fazer. Provavelmente menos horas de docência considerando o esforço e turmas com maior dimensão. (The online teaching format is more difficult for the lecturer than the face-to-face format. The preparation and logistics of online lectures are greater than for in-person lectures, as well as the treatment that is necessary. Probably less teaching hours considering the effort and larger lecture sizes. *)	−1	2
Impacto negativo. Mais exigente para o docente na preparação das matérias. (Negative impact. More demanding for the lecturer in the preparation of the subjects. *)	−2	1

* The answers related to the impact on lecturers' careers were translated to English to allow better comprehension.

The impact of online learning on students' learning has approximately 9 responses with a negative sentiment (14%), as well as a neutral sentiment with 14 answers (21%), and 30 responses with a positive sentiment (46%). The sentiment in relation to teaching activities

has 11 responses with a negative sentiment (17%), 11 answers of neutral sentiment (17%). and 31 positive sentiment responses (47%). In relation to the higher education institution, there are 3 answers with a negative sentiment (5%), 12 responses of neutral sentiment (18%), and 34 positive sentiment responses (52%).

The opinion in relation to the impact of online learning in the institution strategy is the one with a higher percentage of positive sentiment (52%), as opposed to 5% who expressed positive sentiment. The opinion in relation to teaching activities has the highest percentage of positive sentiment (17%) as well as neutral sentiment. The overall sentiment distribution is represented in Figure 3.

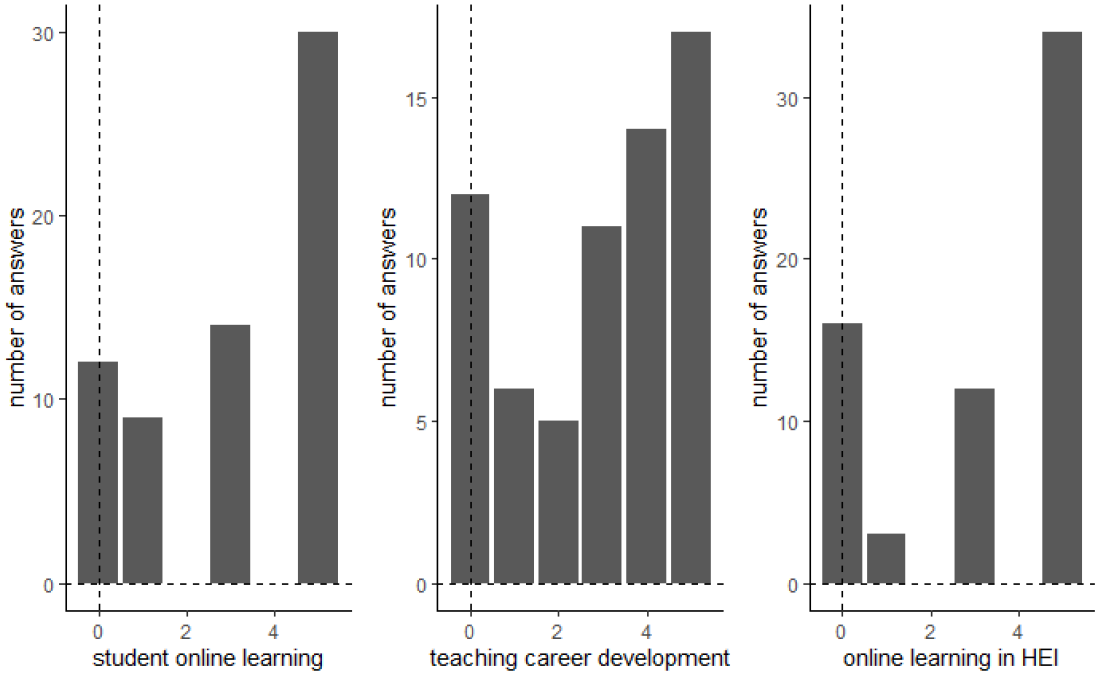

Figure 3. Frequency of the sentiment identified.

4.5. PLS Analysis

The path coefficients of the prediction model were positive in POA (0.390), and they were negative in OTA (−0.169) to the latent variable of OTS. TEX coefficients to the prediction model were positives to the latent variables of OTA and POA. These results show that TEX has direct and indirect (via OTA (0.160) and POA (0.427)) effects on OTS.

The model also presented OTS1 (student online learning) (0.772), OST2 (teaching career development) (0.866), and OTS3 (online learning in HEI) (0.867), which had positive path coefficients to OTS (Figure 4).

Specific indirect effects are show in the Table 11.

Table 11. Specific indirect effects.

Causal Relations	Coefficient Analyses
TEX -> OTA -> OTS	−0.027
OTA -> POA -> OTS	0.110
TEX -> OTA -> POA -> OTS	0.018
TEX -> POA -> OTS	0.167
TEX -> OTA -> POA	0.045

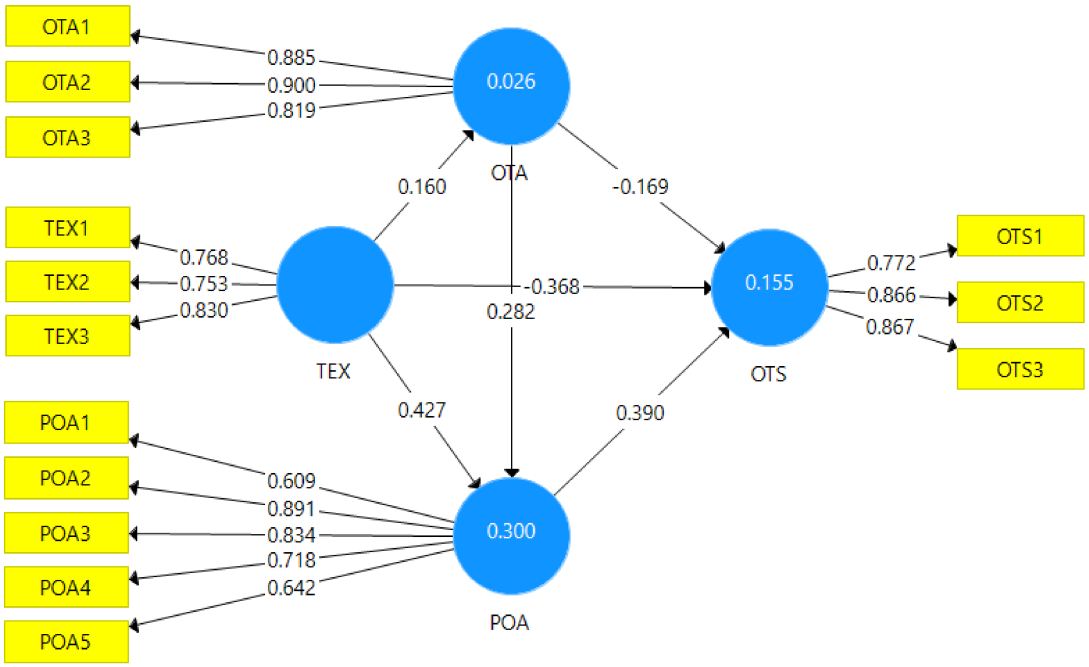

Figure 4. Partial least squares structure model (inner path coefficients and outer weights).

5. Discussion

A questionnaire was conducted with the participation of 66% (n = 65) of all lecturers (98) for a Portuguese private HEI who developed their activities in an emergency online teaching environment. The study examined their attitude toward online teaching, what online activities they most value, and investigated whether technological experience influences these attitude and preferences. The opinions of these lecturers in relation to emergency online teaching, namely their impact on students' learning, their professional development, and the development of HEI strategy was also examined. Finally, a conceptual model was proposed and tested to assess the effect of attitudes, activities, and technological experience on online teaching sentiment. In the following points, the results obtained in relation to the previous literature are discussed.

5.1. Attitude toward Online Teaching

The results showed that lecturers have a positive attitude towards emergency online teaching, showing an identical availability to face-to-face teaching. This conclusion coincides with other studies conducted in an emergency online teaching that show that lecturers report more on the advantages of distance education [53]. This is reinforced by the results obtained in the analysis of the impact of online teaching sentiment on teaching and students' learning.

Based on this conclusion, at least in an emergency situation, lecturers do not question the value of online teaching. Although this is not the same type of education, these conclusions are more positive than the results obtained in a normal situation when questioning face-to-face lectures about their availability and acceptance of online teaching [5,11].

5.2. Preferred Activities

The most preferred activities of lecturers ("online sessions", "oral presentations", and "written assignments") confirm the García-Peñalvo et al. study [15] and reveal that lecturers relied on the "tools" they dominated and only later did they begin to use resources more adjusted to online teaching and learning. This strategy is confirmed by Rapanta et al. [14], who state that many non-specialist online lecturers have chosen to focus on materials/resources that they would use anyway to teach the course content, regardless of whether they are face-to-face or online.

Despite the difficulties related to the emergency online teaching that cannot be compared with "normal" online teaching, some of the options found can be problematized. However, as concluded by Spoel et al. [54], there was the attempt to provide students with the basic ingredients for learning (online lectures, group activities, discussion forums, etc.) that reveal concern with diversification, thus seeking to correspond to the different student learning profiles [22,23].

This adaptability seems to confirm Anderson in that "an excellent e-teacher is an excellent teacher" [2] (p.360), possessing pedagogical skills that allow them to understand the teaching process, in order to be able to make the best use of the range of activities they have at their disposal.

5.3. Technological Experience

Pre-pandemic studies [7,8,10] show that technological readiness can be a factor that conditions the participation of lecturers in online teaching. Although these conclusions cannot be directly transposed to emergency online education, results show that the participants in this study had technological experience in some of the tools for the development of online activities.

5.4. Sentiment Analysis

Lecturers have a positive or neutral sentiment about the impact of emergency online learning on students' learning. These findings are similar to others, where it was concluded that lecturers expressed a favorable opinion about the students' academic performance during the COVID-19 pandemic outbreak [16,17]. The findings of this study are slightly more positive than the results reported by Tartavulea et al. [55], which concluded that emergency online teaching has an overall moderate positive impact on the educational process, albeit the overall effectiveness of the online educational experience is perceived to be lower than in the case of face-to-face teaching.

Likewise, lecturers expressed a neutral or positive sentiment regarding the impact of emergency online teaching on their professional activity. In addition to showing high availability for online teaching, lecturers do not refer to the eventual need for compensation for the required additional work caused by transposition of face-to-face to emergency online teaching, as studies about online teaching reveal [9].

Lecturers thus seem to prefer to take advantage of the professional development opportunity that the situation offers [4]. These conclusions reveal a positive stance that HEIs that intend to invest in online teaching strategies cannot miss. Studies carried out in a pandemic situation have not focused on this aspect, so it is not possible to make comparisons with similar situations. Despite this, there is pre-pandemic literature that shows that lecturers do not consider online teaching as having a positive impact on their careers [4,13].

The results verified in the sentiment analysis about the impact of emergency online teaching for the future development of the HEI are in line with other studies which were carried out outside the emergency context, and where the contribution to organizational change and positioning of the HEI offer are the aspects most frequently pointed out by lecturers on the adoption online teaching [9,11–13]. The extra time and effort invested by lecturers in emergency online teaching can explain the positive perception regarding the impact on HEI strategy [54].

5.5. Conceptual Model

The results of the conceptual model test show that the model has well-fitting conditions. In relation to each of the tested hypotheses it is concluded that five of the six hypotheses have been confirmed (Table 12). The obtained values show that the effect of POA and EXT on OTS, and TEX on POA are strong (>0.35), while the effects of OTA and TEX on POA are moderate (>0.15) [56].

Table 12. Hypothesis results.

Hypothesis	Path Coefficients	Results	Effect
H1: OTA positively affects OTS	−0.169	Not confirmed	-
H2: OTA positively affects POA	0.282	Confirmed	Moderate
H3: POA positively affects OTS	0.380	Confirmed	Strong
H4: TEX positively affects OTS	0.368	Confirmed	Strong
H5: TEX positively affects OTA	0.160	Confirmed	Moderate
H6: TEX positively affects POA	0.427	Confirmed	Strong

5.6. Limitations

Some limitations of the present study must be highlighted. First, the study was carried out in an institution with 98 lecturers, of which 66% submitted valid responses (no missing data). The sample size (n = 65) represents the HEI population, but with all respondents belonging to a single HEI, the study does not allow generalizing the results for Portuguese HEIs.

Another limitation of the study is the fact that the results are based on the respondents' perceptions, which may cause a bias. Although it was clarified that the survey results would only be used for the purposes of the survey, respondents may be tempted to choose the "correct" answer or the more socially desired answer, thus being vulnerable to distortions [42].

The way in which the transition from face-to-face to the emergency online teaching was carried out may justify why lecturers expressed a greater degree of preference for lectures (online sessions). This preference, by itself, could indicate that they merely transposed the "bad" face-to-face practices to the online environment, namely the face-to-face expository sessions. However, despite this greater preference, there is a significant degree of adherence to other activities, namely oral presentations, written assignments (in group), discussion forums, and chat. The diversity and characteristics of these activities can enhance student–lecturer or student–student interaction, leaving good indications about teaching and learning process [2].

The conditions available were certainly not the same in all institutions, just as they are not the same in the face-to-face context. These differences may have affected, to a greater or lesser extent, the quality of the solutions adopted and should be considered as a moderating factor when extending the study to other HEIs.

6. Conclusions

After the emergency online teaching experiences related to COVID-19 pandemic situation, lecturers acquired an experience that will mark their teaching life forever. As the storm passes and face-to-face classes are resumed in a normal environment, HEIs can expect less resistance and more enthusiasm for online teaching from their lecturers [3,4]. So that this enthusiasm does not fade away, it will be necessary to support the training of lecturers by providing them with the skills and competences they require to act in the context of online education. Hybrid approaches integrating online teaching with face-to-face activities can represent a significant improvement when many studies reveal that online education constitutes a key factor for the development of HEIs [4].

This work only reflects the perspective of the lecturers. In parallel, another study is being carried out that will reflect the students' perspective and that will allow a comparison between the two perspectives to be established.

Further research, ideally expanding the sample size with participation of lecturers from different HEIs, is required to verify whether the proposed model continues to maintain theoretical validity. In the same way, this extension will allow confirmation of the findings.

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Article

Mechatronics: Experiential Learning and the Stimulation of Thinking Skills

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Abstract: The development of experiential learning methodologies is gaining attention, due to its contributions to enhancing education quality. It focuses on developing competencies, and build-up added values, such as creative and critical thinking skills, with the aim of improving the quality of learning. The interdisciplinary mechatronics field accommodates a coherent interactive concurrent design process that facilitates innovation and develops the desired skills by adopting experiential learning approaches. This educational learning process is motivated by implementation, assessment, and reflections. This requires synergizing cognition, perception, and behavior with experience sharing and evaluation. Furthermore, it is supported by knowledge accumulation. The learning process with active student's engagement (participation and investigation) is integrated with experimental systems that are developed to facilitate experiential learning supported by properly designed lectures, laboratory experiments, and integrated with course projects. This paper aims to enhance education, learning quality, and contribute to the learning process, while stimulating creative and critical thinking skills. The paper has adopted a student-centered learning approach and focuses on developing training tools to improve the hands-on experience and integrate it with project-based learning. The developed experimental systems have their learning indicators where students acquire knowledge and learn the target skills through involvement in the process. This is inspired by collaborative knowledge sharing, brainstorming, and interactive discussions. The learning outcomes from lectures and laboratory experiments are synergized with the project-based learning approach to yield the desired promising results and exhibit the value of learning. The effectiveness of the developed experimental systems along with the adopted project-based learning approach is demonstrated and evaluated during laboratory sessions supporting different courses at Sanyo-Onoda City University, Yamaguchi, Japan, and at the American University in Cairo.

Keywords: mechatronics; experiential learning; creative thinking; critical thinking; robotics; thinking skills; subsumption architecture; mobile robot; educational system; project-based learning

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1. Introduction

The current era of globalization and the high competition environment has set up a high demand for talent and intelligence requirements. The education quality represents the core elements of success in such competition. Mechatronics classified as a "unifying interdisciplinary and intelligent engineering science paradigm" [1], due to its capability to comprehend and synergize technologies with modern engineering sciences that exhibit quality performance, stimulate creativity and innovations, focus on the interaction of interdisciplinary knowledge, and building up thinking skills through the learning process. Furthermore, it is highly considered as a philosophy and a new way of dynamic work/practices that support new ways of learning to lead to new concurrent design methodologies and innovations [1,2]. Many studies have been conducted to understand

the mechatronics education process and its comprehensive role to establish quality educational requirements and fulfilling future needs creatively. Essential parts of mechatronics education demand to complement theoretical knowledge with practical skills and experience at different levels of the educational process. Such relation aims to develop skills finding creative and innovative solutions, hands-on experience, and practical knowledge, decision-making capabilities at individual and teamwork levels. Hence, among the key features of mechatronics skill-building learning and education is the integration of problem/project-based learning within its structural requirements.

Mechatronics evolved as an engineering science discipline [3] that best reflects interdisciplinary concepts into practice, synergizing knowledge contributed by different disciplines in an innovative way. Mechatronics, with its effective educational process, is contributing to developing capable future creative engineers. Liliana and Florina [4] address the synergy that can be achieved between education, knowledge, and innovation through mechatronics education and its impact on future needs. Acar and Parkin [5] reviewed aspects of mechatronics education and training while comparing the effectiveness of generalist and specialist engineering education.

Researchers published work focused on developing technical tools and systems to enhance experience and skills through training. Akdogan et al. [6] introduced a study tool for teaching and training with a focus on stepper motor as a driving system and its associated techniques using a microcontroller and suitable interface. Camposaragna et al. [7] presented mechatronics educational activity at Bergamo University demonstrated using course projects aiming to teach mechatronics by designing Cartesian plotters. A mechatronics system was developed by Lee and Jung [8] to support learning by using intelligent control techniques. To illustrate the mechatronics intelligent system, an inverted pendulum system was designed and implemented using a neuro-fuzzy control method, based on the Tagaki-Sugeno model. Stockmans-Daou [9], a development system, was introduced, and it constitutes a framework along with automated tools that help to develop reconfigurable mechatronics platforms by combining LEGO Mindstorms systems with a focus on robotics education. Besides, Tokuyasu [10] used Mindstorms platforms and introduced mechatronics installations that provide functional blocks with different capabilities, motors, and sensors. Mindstorms with their sensors are widely considered as an effective toolkit for mechatronics education. Stark et al. [11] developed a low-cost personal laboratory setup supporting learning mechatronics control theory is featured by portability and accessibility. Furthermore, Yilmaz and Tuncalp [12] introduced a mixed learning model that is Web-based and integrates a range of perceptual techniques and methods for effective mechatronics education.

Besides the mentioned work, Sell et al. [13] introduced a methodology with its technical concept that helps students to use mechatronics platforms to support coursework and hands-on experiments through the Internet independent of physical place. The developed platform was demonstrated in Estonia and Germany, and the reflections of the experience were reported by Grover et al. [14]. For the purpose of enhancing microcontroller skills, an undergraduate course was designed for students with different backgrounds. This course was based on a low-cost Arduino platform. Pratumsuwan [15] presented a framework for the final year mechatronics project.

This paper aims to enhance education and learning quality and contributes to learning while stimulating creative and critical thinking skills. The paper has adopted a student-centered learning approach and focused on developing training tools that contribute to improve the hands-on experience and integrate it with project-based learning. This enables students to apply the acquired knowledge in the project to develop new ideas and thinking skills. For this purpose, four educational and experimental systems are proposed to stimulate the learning process of undergraduate students. The developed experimental systems, along with the adopted project-based learning approach, are evaluated in actual laboratory sessions supporting different courses at Sanyo-Onoda City University, Yamaguchi, Japan, and at the American University in Cairo.

2. Paper Contributions and Methodology

The key contributions of this paper can be listed as follow:

a. A review of the student-centered learning approach in developing mechatronics experiential learning to maximize student engagements (participation and investigation) and contributions by stimulating their thinking skills. In this regard, the focus of the paper is not the general standard aspect of experiential learning rather than the way it influences the learning process by having effective synergizing cognition with behavioral learning. This approach aligns the key elements contributing to the quality of learning by facilitating students' inference and help to find out new situations and ways to solve new real-life problems with innovative solutions. This demand to listen carefully to students' feedback and encourage them to have a share in the decision. These demands an understanding of what students' value throughout the learning process;
b. The development of a set of experiments that integrate the necessary knowledge and skills need it in mechatronics as an interdisciplinary field. The developed experimental hardware and associated software alone are not making a major difference compared to the adopted learning process as a whole. Each experiment in the list of the laboratory work represents an integrated process that includes: Experiment set up and troubleshooting, running and results' evaluation, answering attached design problems according to the design requirements. This is going to challenge the gained skills throughout the experiment while stimulating students to develop new skills. Furthermore, it leads to improving writing and oral communication skills;
c. The developed learning process, associated with a holistic assessment, and evaluation approach that looks to assess the overall performance of the student within each conducted learning activity. This also considers student involvement in a part of the assessment process;
d. A guideline for project-based learning that helps to conduct effective and efficient learning skills.

The adopted methodology that has been used to achieve this aims to:

a. Understand the role of experiential learning to build-up hands-on experience and stimulate thinking skills;
b. Develop a student-centered approach that engages students in the learning process at the laboratory experimental level and the project-based learning activities;
c. Develop the necessary laboratory experiments and the necessary mechatronics experimental systems that facilitate students' interactive engagement and experience through open involvement. This aims to develop quality learning skills, and assess the performance of the students at this level;
d. Develop a guideline that facilitates an effective approach to develop an effective project-based learning process that is student-centered to yield quality in terms of innovations and to develop new ideas and solutions. Implement and assess the performance of the students;
e. Evaluate the developed approach and layout concluding remarks.

3. Experiential Learning and Thinking Skills

The trends guiding education for the 21st century are student-centered, experiential learning, technology-infused, and inquiry-based supported by compassion and empathy. Experiential learning is an active student-led learning process through direct engagement supported by experience, analysis, and reflections. It can also be described as an applied creativity, a learning approach that helps to identify the ability of skill and knowledge adaptation needs and applies the required changes to improve and maximize performance. Therefore, experiential learning combined with creative thinking represents the top important requirements featuring future careers.

Creativity is a collection of critical skills that facilitate divergently thinking and enables the brain to generate new concepts, new ideas, and new ways to solve problems. Creativity skill-building can be achieved through different efforts, such as readings, interactive discussion, brainstorming, exercises, experiments, team-based projects, etc. This helps students to assess real problems available in real life in new ways and enables them to find out the best solution, novel product design, and the way to adapt and adopt new technologies. Building creative thinking as a cognitive process enables innovative capabilities that enhance the learning process yielding innovation.

Engineering education supported by doing through experiments and project-based learning methodologies has direct contributions to motivate students' interest, improve their hands-on experience, and positively influence their learning capabilities. Moreover, it facilitates discussion and social interaction, encourage, inspire, and challenge students to improve their ability to apply the acquired knowledge. This approach enables students to use the added value knowledge to develop new skills to design and provide innovative solutions to problems in the real world. Such engagement supported by students' active efforts helps them to build up experience by doing and learning from it, leading to stimulate the brain, enhance thinking skills, and establish creative abilities to develop innovative solutions. In addition, a team-based project helps to create and enhance employability skills at the individual and group levels. Such an approach forms the foundation of experiential learning that aims to conduct hands-on experiments and projects, test and troubleshoots, gather and analyze data, evaluate outcomes, reflect/observe creative behaviors abstracted from the learning novel experience. The creative behaviors stimulate new ideas and solutions that contribute to the enhancement of the learning process and in developing new thinking skills. Furthermore, this has a direct impact on developing professional skills and contribute to achieving the quality of innovative learning, enabling the transformation of new concepts into reality with added value processes, functions, services, or products [16–23].

4. Mechatronics and the Development of Creative Thinking Skills

As an interdisciplinary field, mechatronics is evolved into a philosophy supporting new ways of thinking, interdisciplinary knowledge synergy, work and practices, skills, and innovations [2]. Mechatronics considers education as a social process with a focus to synergize knowledge, establish interactive communications, develop functional skills (through experiments and projects), stimulate motivation, facilitate new teaching techniques, and effectively contribute to the enhancement of student's independent learning skills with the stimulation of strongly couples critical and creative activities as individuals and in teams to bring complementary dimensions to the learning process. This should be supported by an effective exploratory learning environment that focuses on creativity while stimulating a student's motivation. In mechatronics education, the learning process is directly linked with functional skill development that is directly coupled with thinking and creativity. These skills enable thinkers to solve complex problems and work efficiently across different disciplines. In general, current human thinking is not that efficient, based on judgment more than ideas, design, knowledge, and experience. Thinking and creativity are skills that can be developed. These skills require learning it, practicing it, paying attention to it, and gaining confidence. Creative design is a constructive process that looks to develop and implement ideas with new values. Hence, it is essential that students and researchers (individuals and teams) develop their knowledge, experience, and accumulate the acquired creative thinking skills. Besides, engaging them to develop new innovative concurrent design capabilities.

Creative mechatronics as a concurrent and interactive design process helps to facilitate the learning process that leads to the generation of new ideas and solutions to fulfill the demand to maximize the level of creativity supported by creative thinking skills. Evidence of lateral thinking (horizontal) that is classified as deliberate creative skills aiming to understand existing challenges or opportunities, open new possibilities, maximize problem-

solving agility for better or new solutions, and develop new ideas by trying to brainstorm new novel solutions, concepts, and perceptions, while understanding governing rules and constraints. In addition, evidence of vertical thinking involves logical thinking and reasoning, and it includes different functional principles in terms of accuracy, reliability, and geometric structure besides the application of general scientific design principles. In real problem-solving circumstances, a combination of lateral and vertical approaches should be considered to produce the best results. Moreover, practical design with experimental work is an integral part to stimulate thinking, while building up thinking skills. Integrating problem-solving approaches together with creative thinking practices into the concurrent design process of engineering and science projects/products demand not only to change the learning environment and the teaching methods, but it also requires to adopt a new holistic assessment, and evaluation methods [24,25]. Such learning environments contribute to establishing motivation, create curiosity and challenges, imagination, and success in understanding science, engineering, and technology [2].

5. Mechatronics Experimental Educational Systems

A set of experimental systems were developed in association with this paper. The developed experimental system is featured by the integration of the necessary knowledge and skills demanded in mechatronics as an interdisciplinary field. The developed experimental hardware and associated software alone are not making a major difference compared to the adopted educational learning process as a whole. Each experiment in the list of the laboratory work represents an integrated process that includes: Experiment set up and troubleshooting, running and results' evaluation, answering attached design problems according to the design requirements. This is going to challenge the gained skills throughout the experiment while stimulating students to develop new skills. Furthermore, it leads to improving writing and oral communication skills through the assigned presentation sessions.

5.1. Mechatronics Experimental System I

Figure 1 depicts the mechatronics experimental system I that consists of LEDs aboard showing LEDs as ON or OFF, a two wheels' mobile robot with position control. The developed mechatronics experimental system I aims to support hands-on experiments as a part of experimental sessions of the course "Experiments I for Mechanical Engineering" required for second-year students [18]. This course is a three credit-hour course, and it constitutes sixteen laboratory sessions divided into five modules associated with five topics. These are:

- Mechatronics experimental system I
- Mechanics
- Thermodynamics
- Fluid mechanics
- Mechanics of materials

Each module constitutes three laboratory sessions. There are about 10 students per each laboratory session, which is divided into five groups. In general, two students per one group. The remaining laboratory session is dedicated to the group presentation on a selected module and for each group. The laboratory sessions are conducted weekly, and the duration of each is five hours. Accordingly, the laboratory module titled mechatronics experiment I is covered by three laboratory sessions, and that requires a total of 15 h (3 sessions $\times$ 5 h).

Figure 2 presents the board layout of the experimental LEDs. The board has 24 LEDs that arrayed into 8 LEDs per row, as depicted in Figure 3, showing the two output ports B and C, respectively. Lighting and timely flashing patterns can be set using hexadecimal code as required, while the flashing period can be adjusted using Window's timer interrupt or by external triggering. The experiment helps students to learn how to use input-output ports and to design LEDs' flashing using varieties of different flashing patterns by writing

proper computer programs to achieve the desired flashing according to the status of binary input received through sensors or by other means and checked through the input port. Five hours are allotted for this experiment covering hardware and programming skill requirements. Note that the input port A is used to receive the operational state of binary sensors.

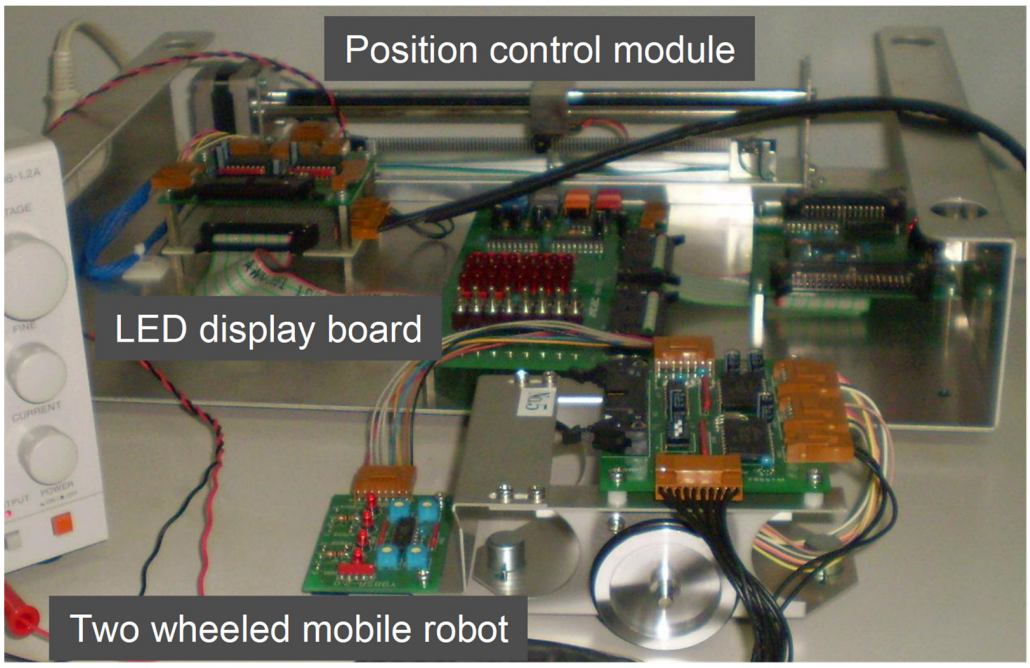


Figure 1. Presents the mechatronics experimental system I5.1.1 Input-Output ports and LEDs flashing experiment: Programing with a timer interrupt.

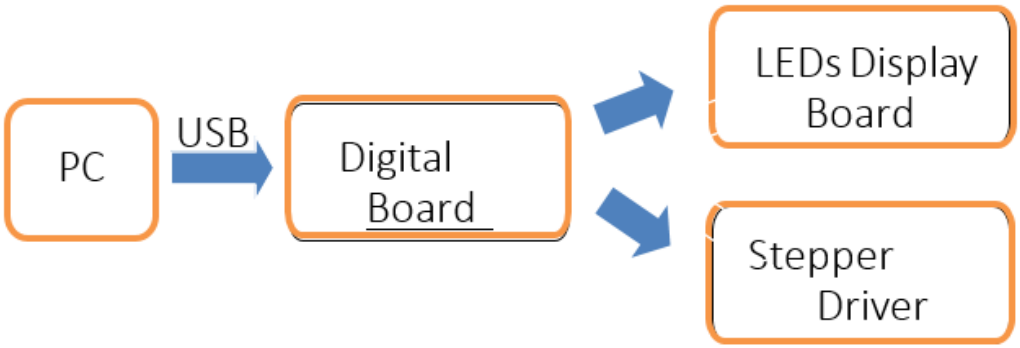


Figure 2. The board layout of the experimental LEDs.

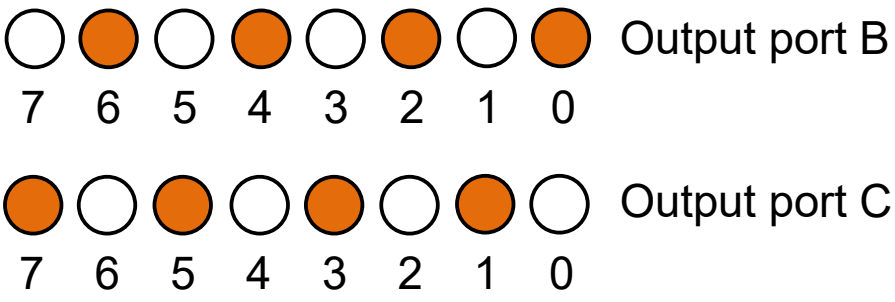


Figure 3. The implemented two 8 bits' output ports.

5.1.1. Experiment on Position Control of a Stepper Motor

The position control module to control a stepper motor is shown in Figure 4. A photo-interrupter is used and fixed together with the leadscrew that is mechanically coupled with the stepper motor. The sensor detects the position of the leadscrew movement through slit positions aligned under the base frame of the leadscrew. The pulse signals generated by the sensor during the movement are used to calculate the actual moved distance and compare it with the pulses sent to drive the stepping motor in steps equivalent to the total desired distance. This experiment helps students to program the motion and understand the effect of stepper motor resolution and the leadscrew resolution with their impact on the traveled distance and the position accuracy. With the implemented position control module and the leadscrew mechanism, each step of the used stepper motor has a resolution of 1.8 degrees/step, and this causes the leadscrew to move by 6.25 μm, based on its thread structure. The desired number of pulses signal representing the desired distance is sent to the motor through port A, and the output port B is used to monitor the actual movement using the photo-coupler (output port B, see Figure 3). Table 1 shows the interpretation of the binary code displayed at port B to that corresponding motor motion action. Students can learn from the experiment how to generate pulses used to drive the motor, how to control the stepper motor, and track the current position of the moving leadscrew. Besides, students (after understanding the hardware structure) work to develop computer programs to control the leadscrew while counting the number of detected slits and find out the position accordingly. Five hours are allotted to conduct this experiment.

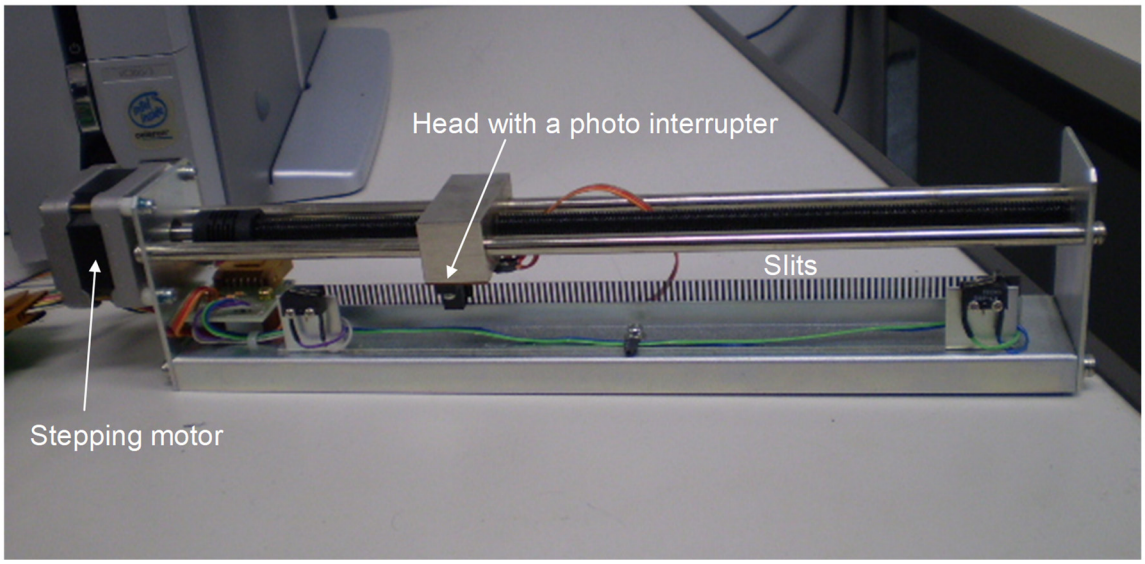


Figure 4. The position control module with leadscrew, stepper motor, and light sensor.

Table 1. 4-bit binary code given to the lower four bits' port B corresponding to the motion type of the stepper motor.

0110	Low level signal for clockwise motion
0111	High level signal for clockwise motion
0010	Low level signal for counterclockwise motion
0011	High level signal for counterclockwise motion
1000	Excitation of motor is OFF

5.1.2. Use of Mobile Robot for Line-Tracing Experiment

Figure 5 shows the used mobile robot with two actuated wheels and equipped with four diffuse light sensors at the front side. The two wheels of the robot are driven by two

stepper motors. The motion of the stepper motors is excited by the binary data coming from received through the output ports B and C to energize the coils of the motors. Furthermore, Figure 5 shows ω and v representing the rotational and the forward translational velocities of the robot, respectively. The robot's rotational velocity is calculated from the angular velocity of both wheels as:

$$\omega = R\frac{(\omega_1 - \omega_2)}{L} \tag{1}$$

where $\omega 1$ and $\omega 2$ are the wheels' rotational velocities 1 and 2, respectively, and the mobile robot is described with respect to its coordinate frame; $2L$ represents the thread distance connecting the centers of the two wheels, while R represents the wheel radius. Furthermore, when generating forward/backward linear motions, it requires only to set the required robot linear velocity (v) and find out the linear velocity of each wheel, $v1$, $v2$, as,

$$\begin{gathered} v = R\frac{(\omega_1 + \omega_2)}{2} \\ v_1 = R\omega_1, v_2 = R\omega_2 \end{gathered} \tag{2}$$

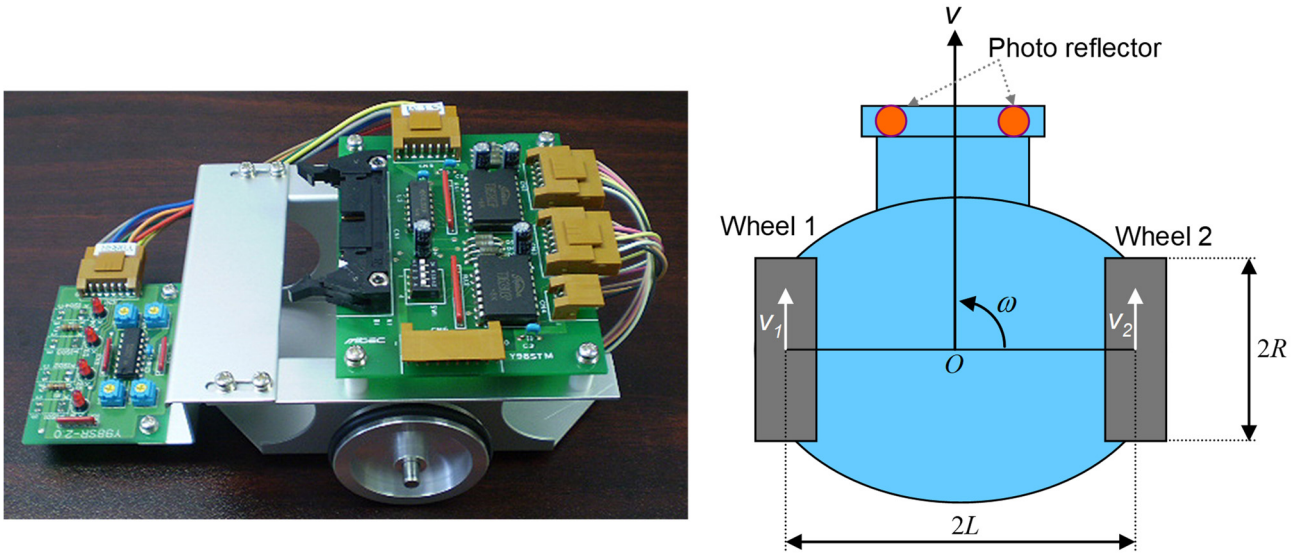


Figure 5. The mobile robot with two actuated wheels and equipped with four diffuse light sensors.

The integrated light reflectors with the robot are used to detect floor color (black or white). The detection status is monitored by checking reflected outputs going to the input port A.

In this part of the experiment, the aim is to enable students to learn how to write basic programs that generate forward/backward motions and instruct the robot to turn left/right while understanding the basic kinematics of a two wheels' mobile robots. In this experiment, students learn how to program the robot to generate the required motion, test and run the programs. Moreover, to write programs that enable the robot to trace a line using the integrated light sensors. Five hours are allotted to this experiment.

5.2. Mechatronics Experimental System II

The second developed mechatronics experimental system is shown in Figure 6, and it consists of three analog sensors that help to measure distance, temperature, and light intensity. Moreover, it has interfaces for AD/DA conversion; also, it is equipped with an LCD panel. Beside this, it has one DC motor and one stepper motor, and a photo-interrupter sensor. The principle hardware is of this experiment is provided through C-TASK Company. The developed experimental module "mechatronics experiment II" system is used to fulfill the needs demanded by the experimental sessions of the course "Experiments II

for Mechanical Engineering" offered at a third year level [26]. The Experiments II for Mechanical Engineering course is a four credit-hour course, and it is conducted for two semesters (one year). It constitutes twenty-six laboratory sessions (13 per each semester). The laboratory sessions are conducted weekly, and the duration of each laboratory session is five hours.

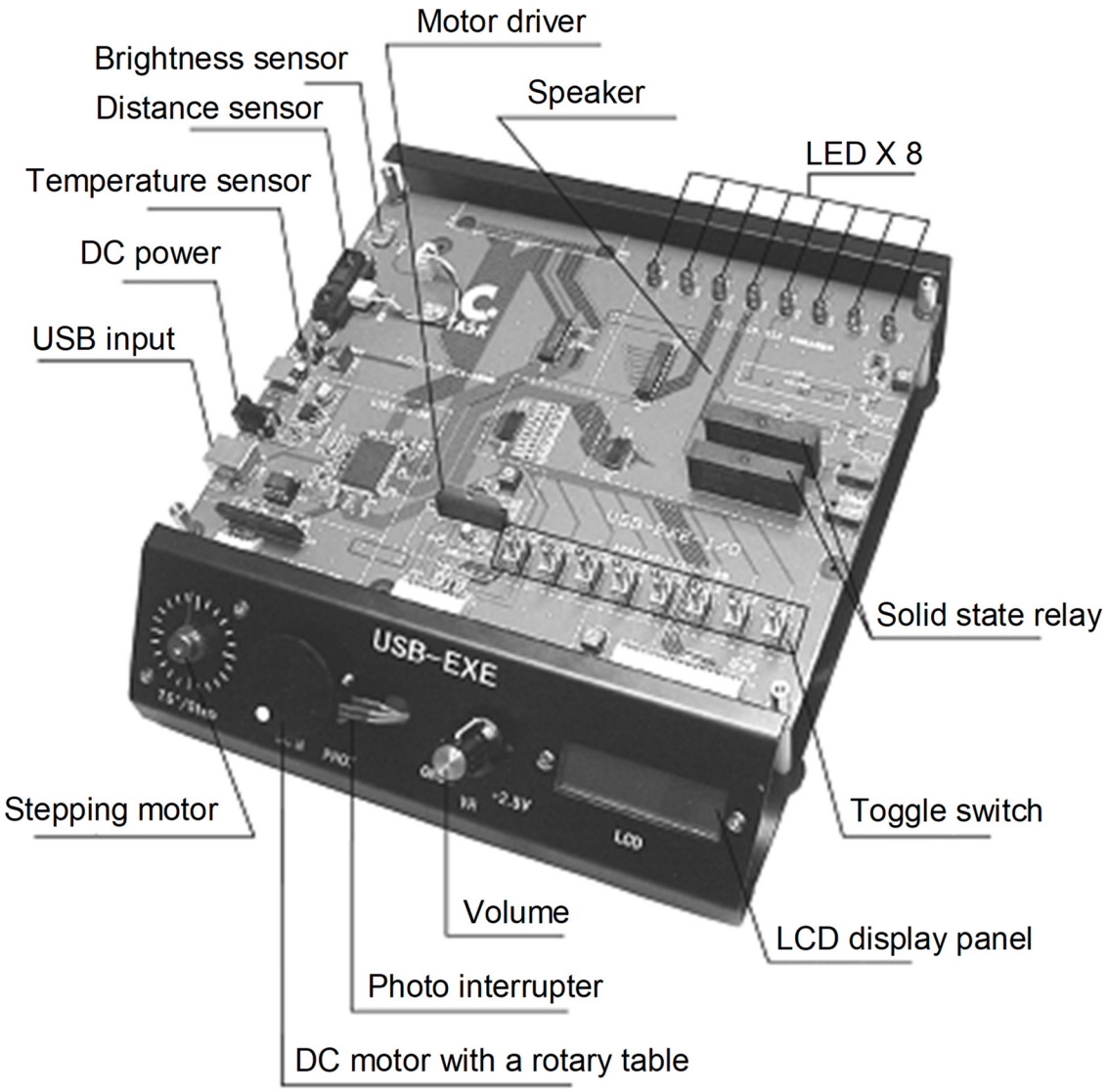


Figure 6. Introduces the mechatronics experimental system II.

The laboratory sessions cover twelve modules supporting twelve topics. Two laboratory sessions are assigned for each module topic. Besides, a laboratory session is assigned for presentation at the end of each semester. The overall topic modules within the course are listed, based on each semester as follows:

For the first semester:

- Thermal expansion of metallic materials,
- Line trace robot using mind-storms,
- Laminar and turbulent flow,
- Control simulation,
- Metallic materials and heat treatment, and
- Boiling experiment and its visualization.

For the second semester:

- Mechatronics experimental system II
- Vibration simulation,
- Articulated industrial robot,
- Metallic materials and tension test,
- Inverted pendulum, and
- Heat cycle and heat exchange.

The first module during the week of mechatronics experimental system II aims to help students learn how to use different analog sensors and convert their output signals to digital through the use of A/D conversion technique. Students in the second week learn how to design a closed-loop feedback control facilitated by a PID control law to control the wheel's rotational velocity. Velocity control software is developed and tested by students for the purpose of this experiment. In addition, the D/A converter used in this experiment is characterized by 8 bits output, and it can accommodate analog signal ranging at least from 0 to +3.3 V. Furthermore, it is necessary to practice how to adjust the output voltage from the D/A to match the need to drive the DC motor with 256 levels (8 bits) of speed control resolution. The DC motor velocity is controlled using a proportional-integral (PI) controller given by:

$$\tau(k+1) = \tau(k) + \Delta\tau(k) \tag{3}$$

$$\Delta\tau(k) = K_p(v_d - v_s(k)) + K_i \sum_{n=1}^{k}(v_d - v_s(n)) \tag{4}$$

where τ (k) represents the DC motor torque's output at the k discrete time; Kp represents the proportional gain, and Ki represents the integral gain of the PI controller; v_d and $v_s(k)$ are the desired rotational velocity and the actual rotational velocity measured at k discrete time, as shown in Figure 7. The actual rotational velocity is measured by counting the number of detected holes at the wheel boundary using the optical sensor.

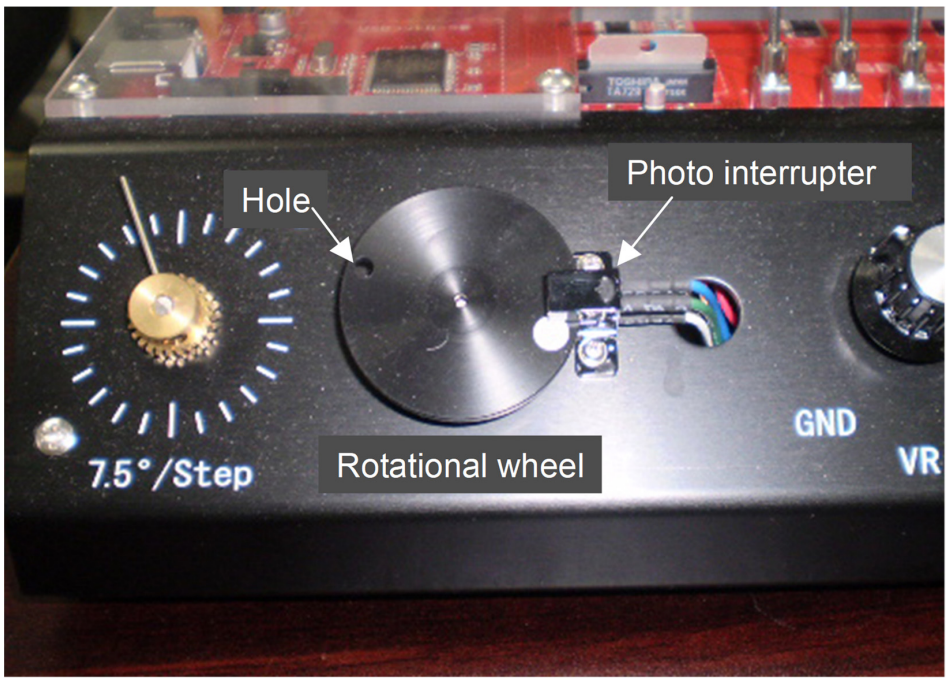


Figure 7. Wheel with a hole and a sensor to measure a DC motor's velocity.

This experiment enables students to design and implement velocity feedback controller described by Equations (3) and (4), respectively. Besides, students experimentally learn to use and understand the characteristics of PI controllers and their control impact on both dynamic parameters and the steady-state error.

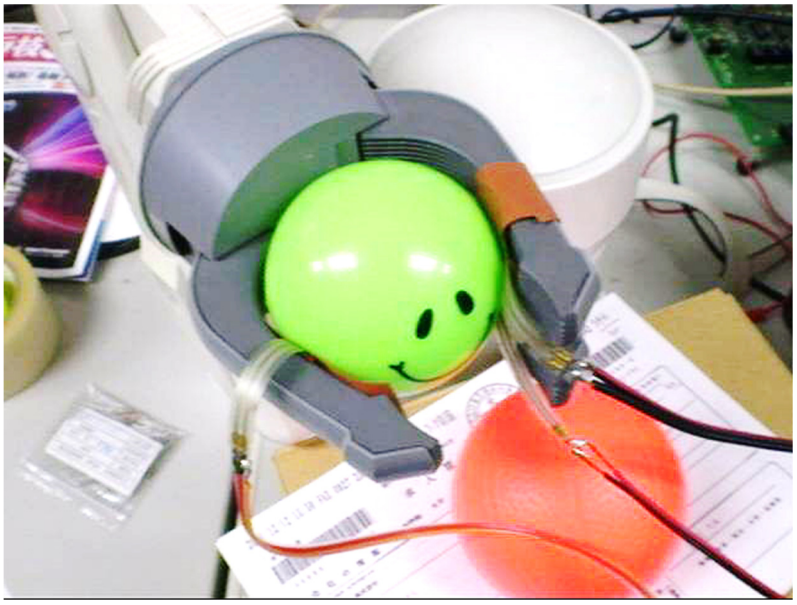
5.3. Mechatronics Experimental System III

Grasping Force and Joint Velocity Control Using 4-DoF Robot

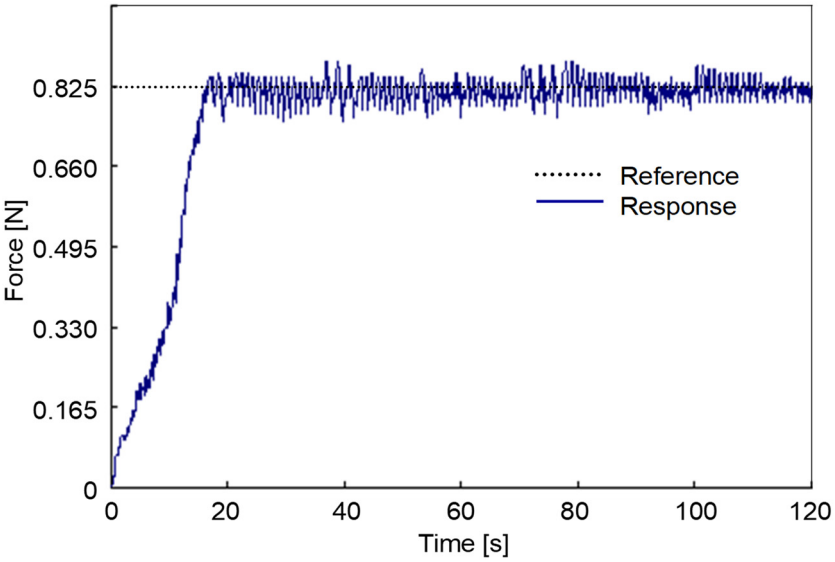
After going through the laboratory sessions of mechatronics experiment systems I and II, students would be able to reflect and build up their creative thinking skills through project-based learning with each course or dedicated for the fourth year senior project course as a requirement for their graduation. The robot's arm is a PC-based 4-DOF, robot and each joint is driven by a DC motor. An example of used robots is called Arm Robot (ABOT), and it is shown in Figure 8. The students used this robot to understand and demonstrate its operation and then learn how to develop a controller to control its joint velocities using Pulse Width Modulation (PWM) technique. In addition, the project aims to enable students to understand the principles of grasping force control using a force sensor placed at the inner sides of the gripper and demonstrate experimentally by programing the robot for this purpose. The experimental layout of the robot is also shown in Figure 8. When the applied force by the gripper force increases, the resistance is representing the physical property of the sensor decreases. Hence, the robot's controller can be programmed to monitor the change in the force by measuring the voltage across the force sensor. The measured voltage is conditioned and converted to digital through the AGB65-ADC converter module.

Figure 8. 4-DoFarm robot used to learn force and joint velocity control techniques.

Figure 9a demonstrates the robots' grasp force control of a green softball. The force control is achieved by controlling either the gripper's opening or closing velocity according to the measured output of the force sensor. Furthermore, Figure 9b demonstrates the desired and actual force control result. The measured force values at each time discrete are plotted to represent the feedback of the grasping motion.



(**a**) The robot demonstrates a grasp force control of a green softball



(**b**) Plot represent the measured force values at each time discrete

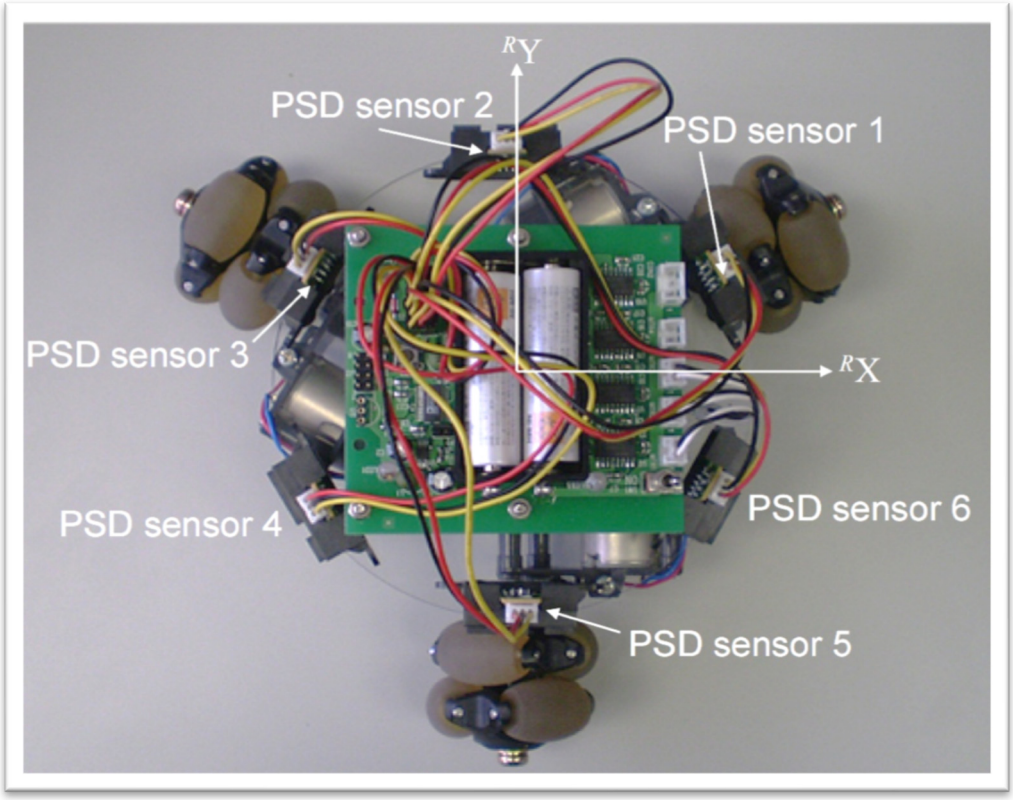
Figure 9. Force control result using three film-type sensors.

5.4. Mechatronics Experimental System IV

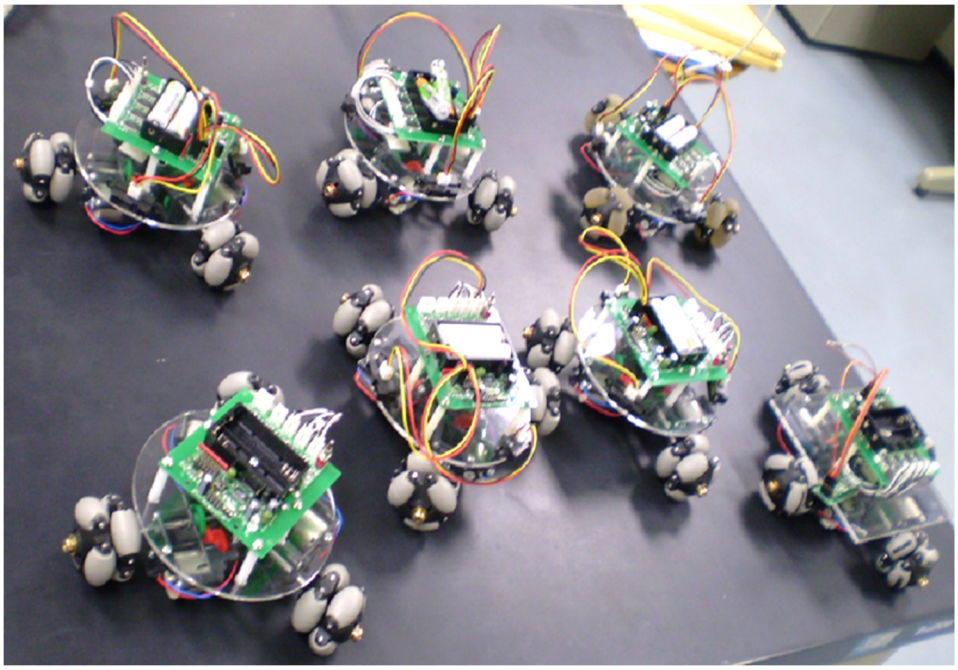
Multiple Mobile Robots System

This section introduces the mechatronics experimental system IV. System IV uses a number of mobile robots to enable these robots to learn the principles of subsumption control architecture and the way to use it to develop schooling behavior. The subsumption control architecture represents the early contributions to developing behavior-based control introduced by Brooks in 1986 [27], and it highly influences the navigation aspect of autonomous robotics development. A robot with three wheels locomotion is shown in Figure 10a, and the is a multi-robotic system using the three wheels robot is shown in Figure 10b. This system is used for the fourth year senior project to enhance their learning of new critical thinking skills through project-based learning, e.g., to develop a new structure of subsumption solving schooling behavior. With such learning activity, students begin to familiarize themselves, and practice the subsumption architecture concept and introduce technical methods to develop the structure of reactive behavior systems. This starts from low level behavior to a higher level behavior using layered sets of rules that

compose reactive behaviors with reference to the demand of the environmental changes and needs.



(**a**) A robot with three wheels locomotion



(**b**) Multi-robots of the three wheels locomotion

Figure 10. Three wheeled multiple mobile robots used for the graduation study.

Table 2 shows the list of command codes and the associated reaction behaviors (reflex actions) that support the navigation of the mobile robots. An agent represents a primitive basic behavior with an assigned priority. Each agent is designed to generate a reflex action based on the sensory information within its priority level.

Table 2. A list of primitive reaction behaviors (reflex actions) selected by mobile robots.

Command Codes	Corresponding Reflex Actions
0	Halt at a position
1	Move to the direction of PSD sensor 1
2	Move to the direction of PSD sensor 2
3	Move to the direction of PSD sensor 3
4	Move to the direction of PSD sensor 4
5	Move to the direction of PSD sensor 5
6	Move to the direction of PSD sensor 6
7	Rotate to clockwise direction
8	Rotate to counterclockwise direction

The developed subsumption-based controller is illustrated in Figure 11. It is composed of four agents, in which the higher execution level priority is assigned to the upper agent. Each small circle with the letter 'S' inside represents a suppression node from a higher priority level to deactivate agent behavior(s) with low priority when more than one behavior agent is activated. The experimental scene of schooling behavior is shown in Figure 12. When schooling pattern modes of the mobile robots are selected, the robots regularly move to follow the inner side of the circular fence while trying to keep a constant distance between the robots and the fence, and also between the robots. This mode enables the behavior of the robots to mimic the carps' movement in a circular artificial Japanese pond. Besides, in case a robot moves along the circular fence in a counterclockwise direction, the control law resulted from "Move forward" agent can be stated as bellow,

$$\dot{X}_i = v\frac{\dot{x_{i2}}}{||\dot{x_{i2}}||} \tag{5}$$

where $\dot{X}_i = \begin{bmatrix} \dot{x}_i & y_i \end{bmatrix}^T$ represents the linear velocity described in the i-th robot, coordinate frame, $\dot{x_{i2}} = \begin{bmatrix} 0 & 1 \end{bmatrix}^T$ represents the normalized velocity for moving to Position Sensitive Detector (PSD) sensor 2, while v is the magnitude of the robot's linear velocity.

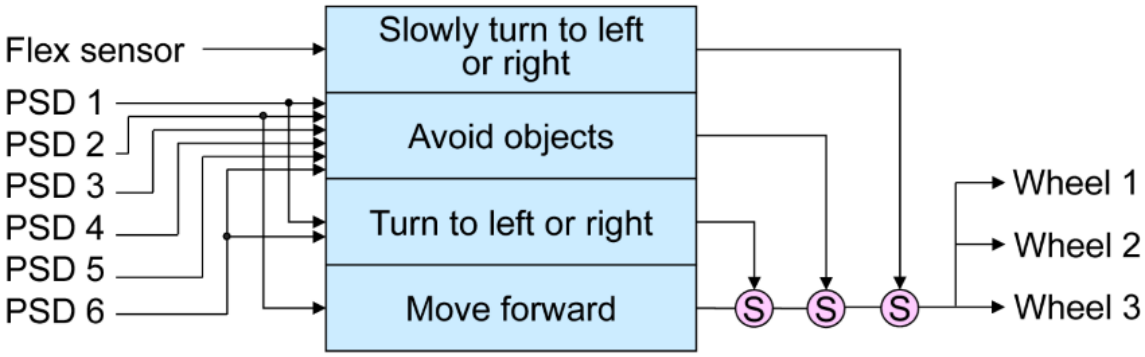


Figure 11. The design of subsumption based control architecture for schooling behavior.

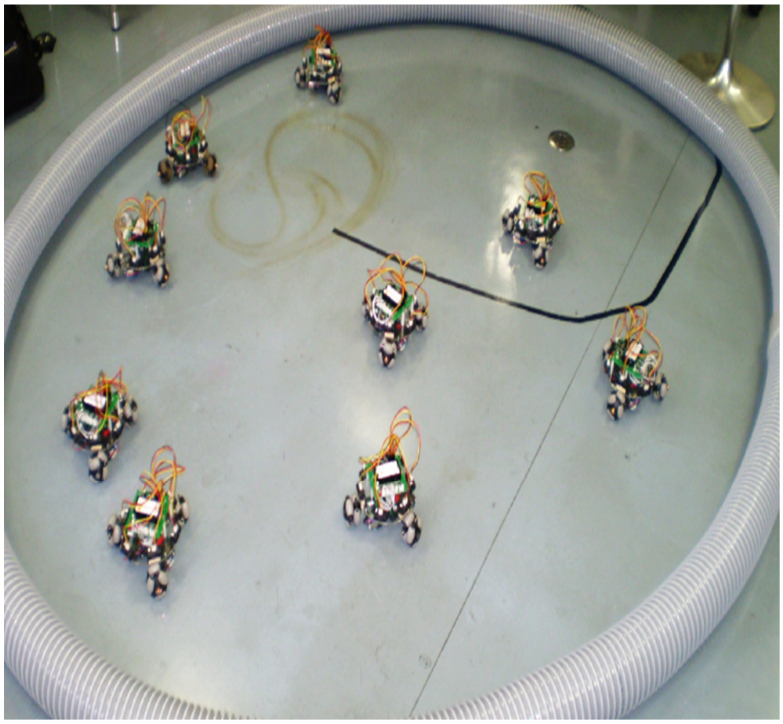


Figure 12. Schooling behavior of multi-robots based on subsumption architecture.

The configuration of the two tactile flex sensors and the six PSD sensors is illustrated in Figure 13. The sensing distance range of the PSD sensor is between a maximum of 80 cm and a minimum of 10 cm. In addition, Figure 14 presents the tactile flex sensor used with each robot. The degree of bending is measured, and the obtained analog signals from the sensors are converted to digital using the A/D converter module.

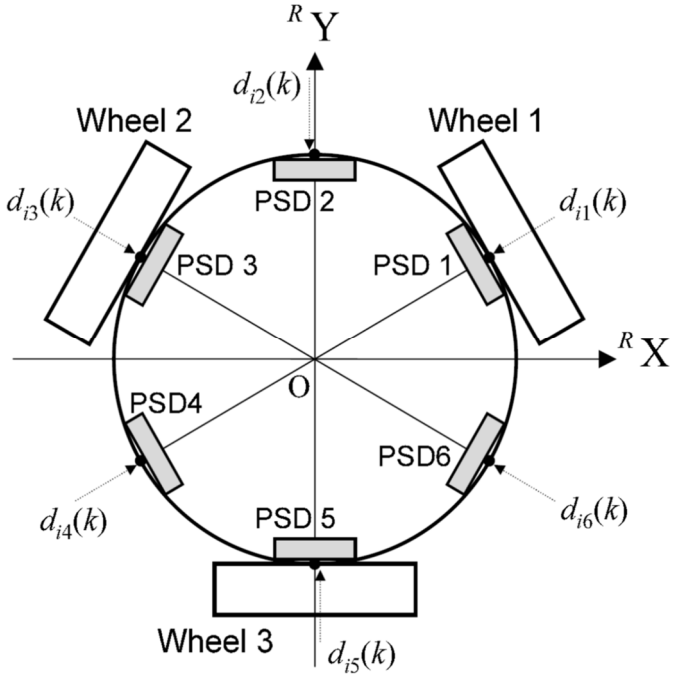


Figure 13. Six PSD sensors are attached to the mobile robot, where PSD 2 position is at the front side of the robot.

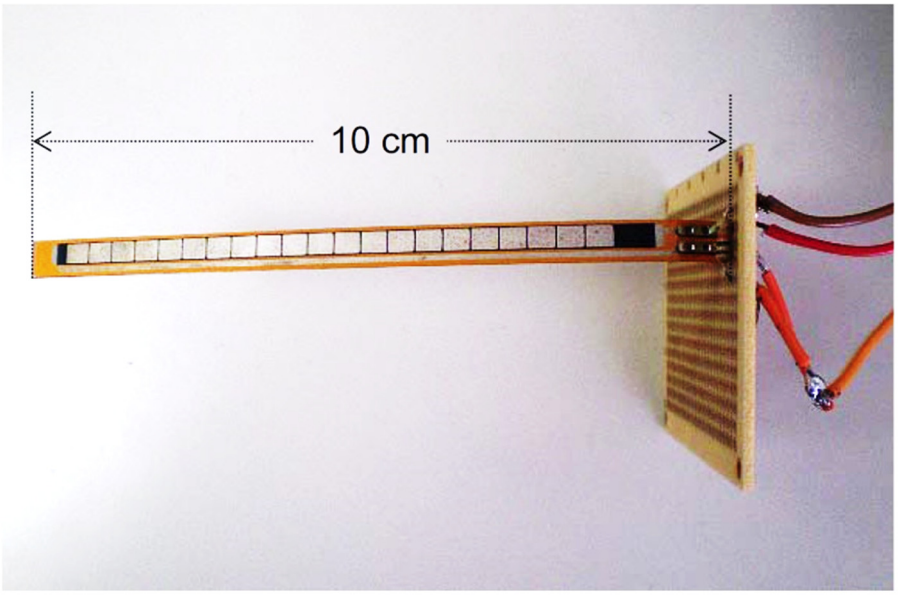


Figure 14. Tactile (flex) sensor with resistance as a physical property.

The robot's orientation of a robot is controlled when by the higher priority agent "Turn to left or right" as

$$\dot{\varphi}_i = K_\varphi(d_{i6}(k) - d_{i1}(k)) \quad (6)$$

where $\dot{\varphi}_i$ indicates to the rotational velocity; $di1(k)$ and $di6(k)$ are the measured values by the 1st and 6th PSD sensors of the i-th robot, respectively; $K\phi$ represents the gain used to keep and control the orientation of the robot parallel to the inner circular fence.

Besides this, the agent behavior "Avoid objects" actuates the robot's wheels to avoid collisions when an object, including other robots, is detected within the effective PSD range. Furthermore, the agent behavior "Slowly turn to left or right" has to be activated when an object is detected by the flex sensor within a range of 10 cm by measuring the readings of fi1(k) and fi2(k). Students can learn the principles of how to build different levels of priorities of agent behaviors for single and multiple mobile robots through the use of the subsumption architecture.

Finally, students' performance associated with lab experiments was assessed using two indicators and the results are shown in Table 3. The results showed positive and effective outcomes.

Table 3. Showing students' performance assessment indicators of conducting lab experiments.

Indicator 1: Ability to Integrate and Test Different Mechatronic Laboratory Experiments from experimental Modules and Basic Components (%)			
Assessment Category	2019	2018	2017
Excellent	69	71	65
Very Good	14	15	22
Good	17	14	12
Satisfactory	0	0	0
Unsatisfactory	0	0	0

Table 3. *Cont.*

Indicator 2: Ability to Develop, Program, Simulate and Analyze Experiments, and Apply its Knowledge Through Problem Solving to Support Learning Needs (%)			
Assessment Categories	During 2019	During 2018	During 2017
Excellent	73	67	68
Very Good	19	25	23
Good	8	8	9
Satisfactory	0	0	0
Unsatisfactory	0	0	0

6. Project-Based Learning

A project-based learning strategy is a comprehensive learning approach aiming to motivate and enhance the capacity of a student's thinking skills [28–32]. The adopted project-based learning approach is an integrated approach demand active student engagement in the investigation that focuses on considering realistic, complex, and open-ended, unstructured problems to coordinate all learning activities to find out innovative solutions to a problem. It is an integrated and holistic learning process the constitutes multiple milestones. These milestones start from team formation, specify the problem to solve, objectives, plan development, debating ideas, constraints, functional requirements (software and hardware), conceptual design, specifications, details design, implementation and troubleshooting, integration, demonstration, conclusions, reporting, and communicating the findings.

Project-based learning is student-centered, and it is facilitated by an instructor who motivates students to learn by applying the acquired knowledge, experience, and interdisciplinary skills through active and interactive engagement for the acquisition of new deeper knowledge and enhance thinking skills, and help to find new ideas and new solutions to solve interdisciplinary real-world challenges and problems that require to seek and use skills and knowledge from different knowledge domains. In addition, project-based learning through its activities helps team members to learn and inspire from each other through collaboration and facilitate deeper learning to represent knowledge and finding new ideas and solutions.

The presented four developed mechatronics experimental systems are used to build up acquired knowledge through experiments. The aim is to integrate the acquired knowledge foundation and enables students to demonstrate freely their skills through practice. It also facilitates a new added value experience with interdisciplinary knowledge from different perspectives while engaging them actively in the project activities. The challenges arise on how to apply such knowledge, skills, and experience through a new context to solving challenging real-life problems with which students never dealt with before. Besides this, it is also necessary to build team-based learning skills to meet professional challenges. Hence, project-based learning is the way to deal with such needs and requirements and fulfill the targeted educational values.

In project-based learning covered by this paper, students were divided into teams, and a coordinator is selected for each team from within to follow up the team interactive and collaborative work and communicate with the instructor. The target is to reflect on and improve their learning added values by developing creative and critical thinking skills, improving writing and communication skills by emphasizing student interest, while giving them the freedom and the responsibility to deliberate through brainstorming and deciding their project topic related to products or systems for each team separately. It is essential to have the communication line open between the instructor and each of the project teams to discuss their concerns, suggestions, and inquiries while receiving feedback on their reports

and reflections. However, the following milestones represent the key stages conducted successfully for the adopted project-based learning approach:

a. For the purpose of assuring collaborative learning, project teams were formed with a size of 3–4 students each. Each team was asked to start deliberate, and think to list (5) topics of their interest without any constraints of time and required resources. Then, arrange the listed topics based on the priority of the team's interest. Hence, the project starts from the seed level by considering the possible topics and uses design thinking supported by an effective strategy to overcome hurdles and reach the final stage.
b. While considering the scope of the listed topics, their requirements, and complexity, the instructor discusses that with each team, and the teams decide their project topic for each. Accordingly, the team prepares a brief report that contains a survey, the technical challenges, scope, objectives, and a methodology to achieve the objectives supported by project key milestones, times frame, with work distribution among team members. In addition, is it important to make the student learn how to reflect on each of the workings steps throughout the development process and also professionally adhere to their plan with the associated timeframe.
c. The next key milestone in project-based learning is developing the conceptual design thinking and design that covers: Technical specifications list supported by technical feedback and user needs from the market as relevant, list of functional requirements, operational scenarios, assumptions, and constraints. Then, a detailed design is prepared. After concluding this stage, a report has to be submitted with reflections on their experience, difficulties, and achievements.
d. Then, the team enters the milestone of hardware selection and software development details, integrates the system, and conducts troubleshooting. Furthermore, this stage is associated with report writing integrated with the previous report while considering the feedback on the earlier submissions.
e. The final milestone is to test and demonstrate the developed system under different operational circumstances, evaluate and reflect on the whole process. A final integrated report has to be submitted, and a team presentation is scheduled and conducted by each team with the participation of each team member. All teams have to attend the final presentation while encouraging interactive questions and answers among the students and with the instructor about the content of each presentation.
f. Documentation is an essential part of the work related to project-based learning that should be going in parallel through all the stages of the project.

According to the experience of the conducted experimental systems, problem-solving and project-based learning during the last three years. Three key indicators were assessed and related to the size of the class between 25–30 students. Table 4 presents the students' performance assessment associated with three performance indicators.

Table 4. Showing students' performance assessment indicators of project-based learning.

Indicator 1: Ability to Design and Analyze the Mechatronic Systems (%)			
Assessment Categories	2019	2018	2017
Excellent	62	66	63
Very Good	23	24	29
Good	15	10	8
Satisfactory	0	0	0
Unsatisfactory	0	0	0

Table 4. *Cont.*

Indicator 2: Ability to Apply Problem Solving Skills and Develop Software Programs to Support Project Solution's Needs (%)			
Assessment Categories	2019	2018	2017
Excellent	69	71	66
Very Good	14	14	22
Good	17	15	12
Satisfactory	0	0	0
Unsatisfactory	0	0	0
Indicator 3: Ability to Build, Integrate and Test a Mechatronic Project-Based System from its idea, Designing to Implementation using Basic Elements (%)			
Assessment Categories	2019	2018	2017
Excellent	65	68	67
Very Good	26	25	20
Good	9	7	13
Satisfactory	0	0	0
Unsatisfactory	0	0	0

Finally, and through the obtained experience in the field, the following guidelines have been concluded to help to guide project-based learning and maximize the learning outcomes:

1. Decide the term and the target learning skills of each project-based learning by defining the problem and the goals. Project term can range from one week, a few weeks, a month, or the full term of a course. The scope and size of the project can vary from one area or topic to another,
2. Form small teams with size between 3–4 of each, and the team assigns one of the team members as a coordinator,
3. Establish a target scope with key outcomes to guide students to deliberate and conclude a list of topics within the announced scope. The instructor should communicate to the students the learning goals of the project.
4. Each team starts to ask questions, and the instructor should listen and answer for the purpose, to clarify the dimensions, prospect, and nature of the project scope, topics, and what they are aiming to solve and obtain. This helps to define the selected topic within the targeted context. In product-related projects, it is necessary to frame the outcomes in a way that benefit the end-users of the targeted product,
5. Each team works to have brainstorming sessions to list according to their interest the possible topics of interest reflecting the announced scope. The role of the instructor here is to help the team to identify and finalize a potential problem/topic, and list the required functionalities, the achievements concluded in the field of the topic, constraints, assumptions, and challenges. The constraints may cover technical, financial, and social are relevant. In order to maximize learning through the project work, it is necessary for the instructor to guide each team to select an unstructured open-ended project topic. It has been proved that selecting and open-ended unstructured problems help students to find out their way to structure multiple solutions to the problem, and this supports collaborative and deeper learning, and helps to develop students' ability to apply the acquired knowledge and adapt it to solve problems that they didn't try before,
6. Develop a plan with key milestones with the timeframe mapped into the project assigned timing. Flexibility is needed with a consultation to adjust the plan, and the

process according to the work progress, the team with the support of the coordinator assigns work distribution among the members for each milestone. Each assigned work should be documented and reported to all team members,

7. Each team starts to discuss different ideas and develops different scenarios for possible solutions, evaluating them with emphasis on the effective one. All students in each team should be engaged inter-team discussions to inspire each other and give them the freedom to state and list their ideas and views. All suggested ideas should be discussed and assessed toward the best solution. Each team is asked to state something unique about the selected idea,
8. The team should develop a methodology on how to implement the selected idea by developing a road map to realize the best solution with possible expansion (concepts, ideas, and visualization). This may include, conceptual design, different forms of prototype development, analysis, etc. This helps the team to uncover possible challenges associated with the selected solution and adjust accordingly through an iterative approach,
9. The instructor should consolidate the work process and progress by assuring the proper number of reporting during the term of the project and assure proper and timely feedback to the team on their progress with suggestions, and
10. In project-based learning, the learning is taken place through a process during the term of the project. Hence, assessing project-based learning should focus on the process through all of its milestones and not just focusing on the final results. The assessment should encourage the students to reflect on each milestone and through the project.

7. Conclusions

This paper focused on the importance of experiential learning and its contributions to utilize acquired knowledge and experience to develop creative and critical thinking skills through its added value activities aiming to improve the quality of students' learning outcomes. In order to support achieving such mainstream goals, experimental laboratory content was designed. The laboratory content was facilitated by the development of four mechatronics experimental systems. The developed systems were used as an effective exploratory learning environment with a focus to enhance the outcomes of the integrated learning process, motivate students through practical design and implementation work, solving real-life problems and stimulate thinking to find out new ways and solutions to solve problems and form new ideas that establish the base of building creative thinking skills which can accommodate the ability for innovations and inventions. These systems enabled students to synergize theoretical knowledge with practical mechatronics technological experience using sensors, motor, control, controllers design, information processing and programming while steaming up students' motivation and enjoyment. Furthermore, a project-based learning approach both individual and team-based were integrated with the developed concepts and the experimental mechatronics systems to enhance students' innovation capabilities through a thinking-based design process.

Although each of the developed systems is simple and primitive, integrating these systems with experiments, knowledge, experience, and skills besides other hardware and software can encourage students to solve complex and realistic problems. Moreover, build complex behavioral agent levels using the primitive ones, improve performance and enhance the outcomes of the learning process. The effectiveness of the developed mechatronics experimental systems I, II, III, and IV were evaluated through the experimental laboratory sessions and project-based learning at the Sanyo-Onoda City University, Yamaguchi, Japan, and at the American University in Cairo. Finally, students were divided into teams and asked to select a problem/topic and apply project-based learning with no given list of project titles. The projects' topics were generated through brainstorming sessions and interactive student-centered discussion by the team members with the final endorsement by the instructor. The selected project topic then went through all nec-

essary design thinking, interactive collaboration, and development processes while the faculty facilitates this process. Finally, students made their reflections about the experience of project-based learning and list the newly concluded knowledge and skills obtained through this exercise, and share this experience with other project groups through an open team-based presentation.

The conclusions through the experiences with project-based learning led to developing effective guidelines that specify the best practices associated with the framework of achieving high-quality learning. Project-based learning should highlight and focus on the value of learning and the learning competencies that lead to better achievements, and not just on the learning as a process. This differentiates project-based learning from just conducting projects. Project-based learning should give students the space to voice out their ideas, discuss them, have fun, interact, and raise concerns and inquiries while they need to be inspired for high-level achievements. The project-based learning, with such an open space of skills and content integration will have (besides the value of learning) a good social impact. Finally, the experience through this work highlight the needs to start shifting to student centered learning techniques. The methodology that encourages students' effective engagement by contributing to lectures, assignments, laboratory experiments, and projects, while the instructor must facilitate, update, and guide the learning process. Furthermore, assessing students' performance and activities in a course should be considered holistically by looking at students' achievements as a whole.

To address the educational and teaching needs during the Covid-19 pandemic, the developed mechatronics experimental systems can be integrated remotely as an option to support remote teaching.

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Article

Student Burnout: A Case Study about a Portuguese Public University

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Abstract: Burnout is increasingly present in organizations and in the most diverse professions, namely, in university students. Burnout can have negative repercussions on their well-being and can even lead them to abandon their studies. The objective of the study focuses on academic burnout and taking medication as a consequence of the requirements of the academic path of students at a Portuguese public university. To achieve this goal, a quantitative methodology was used, consisting of the distribution of a questionnaire to a sample of students from the analyzed university. The first study questionnaire obtained 207 responses, all valid. To perform the analysis of the quantitative data, the program IBM SPSS Statistics, version 25 was used. Inferential statistics were used, namely, Student *t*-test and one-way ANOVA (parametric tests), Spearman's correlation coefficient, and the Chi-square test, to test the previously defined research hypotheses. Among the variables for which statistically significant relationships with burnout were found, the following stand out: the arithmetic mean (course average); the professional situation; participation in extracurricular activities; the practice and frequency of physical exercise; the choice and expectations regarding the course; the uncertainty felt about the professional future; the evaluation of the relationship with colleagues.

Keywords: academic burnout; stress; higher education; quantitative research; coping strategies; medication

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1. Introduction

All individuals need to acquire fundamental knowledge and skills throughout their lives, and in particular, to exercise a profession. In an increasingly demanding world, the attendance of higher education is, for many, essential. However, nowadays, there are high levels of stress associated with university life and the environment of higher education institutions [1], and university students, exposed to highly competitive environments and sometimes precarious working conditions (in the case of student workers), are among the large portion of society that suffers from this complex state of mind.

According to [2], it seems frequent that, when entering university, students start by feeling only low levels of stress, caused, above all, by the uncertainties associated with the chosen training path and the type of instruction they face in the University education. The author states that this same stress tends, however, to increase with the progression in the academic path and with the intensification of the required work. The growing burden of study and responsibility also tends to add social and family pressures related to the desire for students to finish their study cycles successfully [3], as well as pressures derived from economic factors, cultural factors, and even aspects related to the personality of each student [4].

Among the factors that cause stress in young people are the significant changes that students go through in the transition periods from primary to basic education, from basic to secondary education and, of course, from secondary to university education. It is known

that it is precisely during these transition periods that students are most concerned with failure, with the future and with aspects such as the expectations of their parents, the possible end of a relationship or the distance from friends [5], all sources of pressure that can generate conflicts within your family.

On the other hand, among the various factors that generate stress and anxiety in modern society, there are also issues related to employability, namely, the unemployment rate of individuals with a higher education degree, which can have severe social, economic, and political consequences [6].

It is therefore imperative not only to understand what the consequences of stress are in a university context, but also to study how the growing concern of these students can cause harmful effects on their academic performance.

It is known that, today, one of the most common negative effects in the university community is academic burnout [7,8], which is a response to stress related to this specific environment, and which affects "the development, understanding and satisfaction of the student with their education and academic life" ([9], p. 4).

The academic burnout syndrome can be understood as the state in which a person is when subjected to long periods of work and stress, particularly caused by the questionable working conditions that he faces in the environment of the university institution in which he is inserted. These conditions can materialize in the lack of resources, in the high competitiveness among colleagues and in so many other factors that negatively influence the performance of any activities carried out in this area [10].

Now, all the peculiarities inherent to university life can cause students to develop syndromes such as burnout, directly associated with fatigue and emotional exhaustion [11], or other disorders of psychological well-being, related to the level of happiness and ideal personal development of students [12], a path that, in turn, must be free of psychological diseases and that implies reaching its full potential.

In the specific case of burnout, the student ends up facing academic life feeling disinterest and frustration, which, according to [4], has physical and emotional manifestations that are often accompanied by evasive behaviors and symptoms that mirror this discomfort. Some of these symptoms are identified: constant tiredness and fatigue; mental exhaustion; lack of ability to nurture their personal relationships; social distancing; complex mood states (such as anxiety, irritability and, in some cases, mild depression); difficulty in being focused or attentive during any task; weight loss and muscle spasms; hormonal and metabolic disorders; allergies and migraines; and insomnia and abuse of psychotropic and narcotic substances, alcohol or other drugs [10].

As can be seen from the symptoms linked to the aforementioned physical and psychological suffering, burnout is a worrying state of health, with many harmful effects [13]. Many of these symptoms are associated, in the case of university students, with a worse understanding of the subjects taught, with the low expectations of these students, with the (eventual) failure to obtain the desired academic degree and with the growing tendency to abandon the professional career for which the degree was initially chosen, as mentioned by authors such as [14,15].

However, and although it is difficult to avoid stress in some scenarios, certain authors, such as [5], believe that it is possible to learn to live with it, reducing the harmful social consequences and the pathologies that so often result from it.

In this sense, higher education institutions have an essential role in preserving the health of their students, since they are the key element in the higher education sector. Students participate in the process of producing scientific knowledge and are, at the same time, users of the teaching processes involved in it, representing an important part of today's society, considered to have a critical spirit and creativity [5].

Study Objectives and Research Questions

In view of the introduction above, with regard to burnout, the aim of this study is to fill a gap in the scientific literature on this topic. Thus, an analysis of academic burnout

in a Portuguese public university is carried out and the frequency with which university students of that institution take medication, from multivitamins to stimulants and/or hypnotics, hypnotics are sleeping pills [16], is investigated in order to try to respond to the demands inherent to that environment.

When tracing the current scenario, it appears that the impact of academic burnout is one of the main factors that affect the professional and personal success of students. For this reason, it is intended to propose, following this analysis, some important recommendations to reduce burnout and to improve the quality of life of students, through the implementation of reforms in higher education.

Ref. [17] refer that, in an empirical study, it is crucial to clarify the research question that is intended to be answered and that will lead to the research work. With this in mind, in order to achieve the empirical knowledge objectives listed above, the following research question are defined: "Do students at the Portuguese public university experience burnout and take or have they taken any medication during their academic career?".

The subject of the present investigation is relevant, since, in Portugal, a significant number of investigations directed to this theme has not been carried out, still less focusing on the public institution studied herein, according to the research carried out in the database SciVerse Scopus (Elsevier) (bibliographic database). Its relevance is also shown by the growing challenge that burnout and taking medication represent for universities, as will be seen below. Both phenomena have relevant economic and social implications, since students who are in a state of burnout are more likely to give up their studies and, therefore, will not be able to make a good contribution to society, as they will not develop their skills and capabilities to their full potential.

In this sense, the main research objectives of the present study are

(1) quantify the degree of academic burnout among students at the Portuguese public university;
(2) assess the prevalence of taking antidepressant, anxiolytic, multivitamin, stimulating and/or hypnotic medication among students at the Portuguese public university, during their academic career;
(3) list the main factors that determine the taking of the same medication;
(4) to analyze the relationship between the sociodemographic characteristics of the community under study and the academic burnout experienced by it;
(5) identify the way students perceive academic burnout and taking medication throughout their university career, identifying the sensations they try to reduce by taking medication;
(6) to propose some important solutions to reduce burnout, as well as improve quality of life and increase student satisfaction;
(7) understand how researchers in the field interpret burnout and academic burnout;

The objectives are achieved through the application of a quantitative data collection methodology, more precisely through the application of a questionnaire to students of the Portuguese public university under analysis and through a literature review on the subject, based on a previous documentary survey.

2. Literature Review

2.1. Burnout Definitions

There are many studies that present definitions of burnout, in its broadest sense, and there are many nuances around them. However, it was [18] who, during the exercise of his activity in psychology, in the 1970s, popularized the concept of burnout, after witnessing a decrease in motivation and commitment in individuals who volunteered at a mental health clinic.

Ref. [18] also referred that, in the work context, burnout is a combination of factors, such as chronic emotional tiredness, physical tiredness and a lack of interest in work activity, low personal fulfillment and insensitivity in the care and attention towards the user. This idea was corroborated by [19], who defined the syndrome as the result of

excessive stress in the work context, in a context in which evidence of emotional tiredness and lack of emotional resources is evident and which is manifested by: a negative response and disinterest in other people; loss of idealism (depersonalization); and a reduction in feelings of competence and job performance (low personal achievement).

Ref. [19–21] state that burnout is a state that results from a continued irreconcilability between an individual and, at least, one of the six dimensions of work listed below:

(1) Workload—when there is excessive workload and demands, and recovery cannot be achieved;
(2) Control—when workers do not have sufficient control over the resources needed to complete or carry out their work;
(3) Reward—when there is a lack of adequate rewards for the work done. The rewards can be financial, social and intrinsic (for example, the pride someone experiences when they know they have done their job well);
(4) Community—when employees feel that they do not establish positive connections with their colleagues and guardians, leading to frustration and decreased social support;
(5) Justice—when injustice is felt in the workplace, including inequalities in workload and wages;
(6) Values—when employees feel constrained to act against their values and aspirations, or when they experience conflicts between the organization's values.

According to Velasco, J.C. [22], burnout is characterized, not only by the reduction of motivation and job satisfaction, but also by health problems, family and social conflicts, and by the decrease in productivity of individuals who suffer from it.

There are also authors, such as Rosales, Y. [23] who choose to categorize the effects of burnout in three groups: the psychosomatic, the behavioral and the emotional. In the first group, the author includes symptoms such as a change in heart rate, extreme fatigue, or headaches. In the second, it includes drug or alcohol abuse and absenteeism. Finally, in the third group, Rosales, Y. gives as examples the lack of motivation to study and the withdrawal from studies in the academic context.

As can be seen, although there is no consensus regarding the definition of burnout, there is agreement that this syndrome is the result of an effect and response to chronic stress in the work or academic context, which is characterized mainly by three dimensions: exhaustion, depersonalization and low personal fulfillment [24]. Ref. [25] even face burnout as a public health problem and, therefore, recognize that is has significant severity.

2.2. Academic Burnout and Factors Responsible for Burnout

Both burnout at work and academic burnout are a complex result (motivational, cognitive, emotional, and behavioral response) of a process of accumulation of chronic stress, developing due to the particularities of the context, academic or professional, and of the individual [26].

Ref. [27] indicate that, in the work context, the imbalance in professional life, overwork, depression, interpersonal conflicts, and a decreased sense of self-worth are some of the risk factors associated with the occurrence of the syndrome.

In an academic context, there are many factors responsible for its presence. According to some studies carried out in Australia, Canada, and the United Kingdom, the experience of the transition from secondary to higher education is, for example, a stress promoter, during and from the first year of post-secondary studies, with a propensity to increase in individuals entering university, for financial reasons, or associated with the competitiveness they face, among others [28].

Academic burnout is one of the most important educational research themes today, mainly because its prevalence has been increasing over the years [27,29]. The analysis of academic burnout can be the first step to understand the behavior and academic performance of university students, as well as to understand their level of commitment to

learning, their level of participation in the world of science and how it can affect the enthusiasm for their training [30].

According to [25,31], academic burnout consists of the feeling of cognitive and emotional exhaustion caused by the high demands of a university. Among them, university students are required to attend classes, perform assignments, exams and presentations, actively participate in the classroom, and interact with people and the educational establishment.

This excessive academic burden can have serious consequences on the physical and mental health of the student, who may not yet have an appropriate psychological structure to respond adequately. Thus, feelings of incapacity and incompetence on the part of the students may arise and, of course, a posture of disbelief, not only in relation to teachers and colleagues, but also in relation to studies and the objective of their training [31].

In addition to the academic background, studies such as those by [32], among many others, point to the fact that the social and professional pressures related to the financing of higher education, school performance, and poor relationships with colleagues and teachers are some of the factors that make college students more vulnerable to the development of this syndrome.

As can be deduced, there are many variables associated with burnout and, in this sense, authors such as [33] establish, in the particular case of academic burnout, categories of academic, environmental, and/or social context and intrapersonal variables (Figure 1). In Figure 1 it is possible to observe each of these categories of variables, illustrated by some examples.

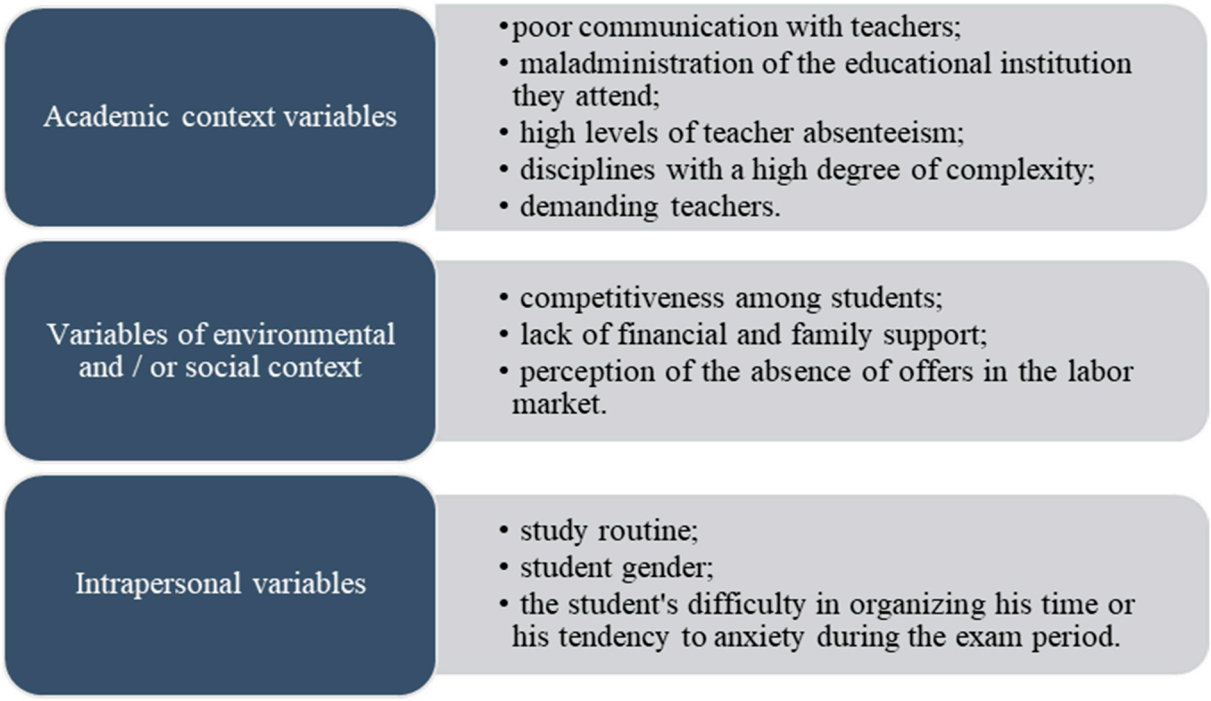

Figure 1. Categories of variables associated with academic burnout and respective examples [33].

The existing research on the predictive variables of burnout focuses essentially on the work context and not so much on the academic environment [9]. Ref. [34] present three groups of predictive variables related to the development of burnout in the work context: of an organizational, social, and individual nature, which can also be applied to the academic context.

There are some risk factors with regard to organizational aspects, which hinder the students' good academic performance, and which positively correlate with higher levels of burnout [34], among them, the difficulties with library and reprography services; the

absence of logistical support and infrastructure, namely, classrooms with scarce computer equipment, inappropriate ventilation, poor lighting or inappropriate furniture; or poor transport conditions for traveling to the school [9].

Additionally, the lack of financial support to study, in particular, the difficulty in obtaining scholarships provided or channeled by the university; the insufficient empathy and efficiency of administrative staff; organizational inflexibility; the difficulty in collaborating in decision-making; and the absence of an academic association, are other difficulties that arise for students, at the organizational level [9].

On the other hand, there are certain peculiarities of the student's work that may be controllable, or that are subject to the intervention of the higher education institution. Some of them are, the overload of disciplines and high academic demands; the frequent absence of explanations and clarifications indispensable to the elaboration of academic activities and work that imply greater concentration, or whose contents are complex; demanding and/or absentee teachers; the student's lack of control or autonomy over his work; the inappropriate distribution of the workload throughout the semester; and carrying out training activities and/or curricular internships at the same time as classes take place [35].

It is important to note that, when analyzing the student's task or activity factors, one must take into consideration the type of profession that he intends to pursue, or the course he attends, since burnout is more prevalent in some of the professions and/or courses, as will be seen below [35].

Regarding the social risk factors, in the academic field, which may precede or allow foreseeing the appearance of the burnout syndrome, empirical investigations emphasize the following: the poor relations between students and teachers, the absence of feedback from teachers, reduced solidarity and companionship, competitiveness and conflicts with colleagues, non-participation in cultural or recreational activities, and recreational spaces that are difficult to access. In addition, interpersonal factors also play a crucial role, namely the absence of family support and the absence of friendships [36].

On the other hand, [9] point out other aspects as more viable to predict burnout cases in university students, namely, sex (given that women are more effective and men more cynical in relation to their training), certain traits of personality (anxiety, stiffness, perfectionism, and low levels of self-efficacy; self-efficacy being an individual's belief or confidence in their own ability to perform a particular task or solve a particular problem [37]), and certain methods of measuring student academic performance, such as skill deficits, habits, and study methods (for example, to do a job, organize time, or speak in public). In addition, feeling anxious during exams, having poor social and cognitive abilities, and low prospects for academic success, as well as less motivation or satisfaction with the studies, are other aspects that, according to these authors, may precede a condition of burnout.

The identification of academic burnout, according to [38], may involve assessing the longevity of each student's studies, as well as recognizing certain attitudes, guided by cynicism and incompetence. In addition, some studies, such as those by [20,39,40], prove that people's personality, their social support and coping strategies are variables that allow for the predicting of burnout. However, there do not seem to be many investigations that analyze these variables in university students [41].

In short, it is possible to affirm that academic burnout is characterized by three dimensions: emotional exhaustion, disbelief, and low professional effectiveness, data confirmed by the analysis of several samples of university students from different countries and areas of training [31,32]. University students suffer from emotional exhaustion as a result of a feeling of exhaustion in face of the demand for studies. Disbelief, on the other hand, is present when a cynical and distant attitude towards studies is developed, and low professional effectiveness arises when the student cultivates the idea that he is incompetent [32].

2.3. Implications and Consequences of Burnout

Several studies show high stress, anxiety and depression among university students. In an attempt to respond to increasingly intense academic and social demands, namely, meeting new people, facing new responsibilities, adapting to new circumstances and increasing work demands [42], these students are more susceptible to syndromes such as academic burnout and to all the personal and social consequences that they can experience in their lives [43].

As ref. [44] point out, academic burnout can make it difficult for higher education students, expected professionals of the future, to graduate, which in turn can have a negative impact in the way they will exercise their professions or even lead to total failure with regard to finishing their cycle of studies and, later, entering the world of work.

In fact, according to certain authors, in university students, this syndrome is associated with poor cognitive performance [45], with reduced academic achievement or dropping out of school [46], and also to depressive symptoms [47] and even suicidal thoughts [13].

Now, if burnout causes low productivity and less student motivation [48], then it is negatively related to the performance of these same students [49]. Hence, students who suffer from burnout are more likely to manifest anger, difficulties in overcoming obstacles and, also, sadness [50].

On the other hand, university students involved in their study cycle in a relaxed and positive way have a better academic performance [51], showing themselves to be energetic, happy and, consequently, being more successful in their learning path.

According to [52], there are still several studies that prove that burnout has several effects, which can be severe, on the well-being and health of individuals.

In fact, burnout syndrome appears to be a considerable predictor of various illnesses and health disorders such as hypercholesterolemia, type 2 diabetes, obesity, coronary heart disease, cardiovascular disorders, musculoskeletal pain, prolonged fatigue, headaches, insomnia, gastrointestinal problems, breathing problems, and psychological changes, such as depression or mental disorders, among others [52].

According to the aforementioned authors, there is also a link between burnout and the adoption of unhealthy lifestyle habits, materialized, for example, in the increase in alcohol consumption and inactivity. In addition, other signs of the burnout syndrome are, according to [53], occupational problems, such as job dissatisfaction (for example, looking for a new job), absenteeism or disability.

2.4. Burnout, Motivation, and Low Academic Performance in University Students

The main objective of students is to obtain a good academic performance, which is what defines the progression in their studies. However, this performance is the result of an emerging product, composed of interdependent factors of various types: volitional, affective, cognitive, behavioral, and psychosocial, of the student and their learning circumstances. These factors include the conditions of the teaching institution itself, which also interfere with the student's teaching–learning relationship; the student's knowledge or study skills; and the pedagogical training materials provided for this performance [33,54].

If, according to [55], one of the causes for burnout may be the loss of motivation, according to [56], on the contrary, an extreme motivation is a kind of prerequisite for suffering from burnout. Therefore, the question of whether low or high motivation is a very limiting (if not controversial) aspect to assess the likelihood that an individual will suffer burnout [57] seems pertinent.

Ref. [58] ensures that students who are intrinsically motivated are less likely to suffer burnout than students who have extrinsic motivation. Ref. [59] corroborate this idea, stating that extrinsic motivation even tends to increase academic burnout, and an intrinsically motivated student is less susceptible to the development of this syndrome [57].

According to [60] extrinsic motivation comes from outside a person; that is, the person works to obtain external rewards, money being the most common of them. Intrinsic motivation, on the other hand, is the internal desire to do something, the person being

driven by interest, satisfaction, and the challenge of his own work, and not by external pressures.

For the author, intrinsic motivation is more important in creativity and in the work context than extrinsic motivation. In the same direction, studies by [61] corroborate the idea that intrinsic motivation plays an important role in overcoming the negative cycle of burnout. Additionally, according to [62], individual motivations have a considerable influence on the burnout cycle. Other authors such as [63] have even shown that the relationship between workload and burnout in university students is almost non-existent, but that academic motivation can effectively prevent burnout.

Therefore, the role that motivation plays in learning seems to be indisputable, namely, because it is responsible for the good involvement of students in academic activities, which require effort and dedication [64–66].

Refs. [67,68] point out four major sets of motivational theories as those that can explain the role of motivation in learning: (1) the first, focuses on beliefs about competence and expectations of students, both in terms of their success as well as their failure to obtain results; (2) the second, focuses on the motivations that lead individuals to perform certain activities (that is, the objectives with which they perform them, the intrinsic and extrinsic motivation or the values that motivate their involvement in these activities); (3) the third, encompasses students' expectations and values; and (4) the last set of motivational theories takes into account the relationship between motivational and cognitive processes.

It is crucial to understand motivation as a multidimensional construct that is explained based on the influence of the social environment and cognitive components [64–66], being a variable with a very important role both in theory and in practice, and which parents, guardians, teachers, and educators themselves often turn to, in order to clarify students' behaviors, their school performance and the quality of their learning [69–71].

Albeit it is also important to realize that academic motivation is a process that requires activation, direction and persistence, and in which the components of value, expectation and affection play a major role [72]. Note, for example, that when a student is confronted with a particular academic task, he may wonder about the reason or objective for which he should perform it; the greater the interest and usefulness you see in it, the greater the value you will attach to it and the greater your involvement in it. At the same time, the student will feel, or not, capable of carrying out the task in question, taking into account his personal resources, which may not be sufficient, making it necessary for him to be able to cultivate a certain belief that he is qualified to perform everything that this task implies. Finally, the third dimension of motivation to consider is the affective component; that is, the one according to which the student gets involved in a task and assesses the feelings and emotions that it provokes: if he feels confident, he will have the courage to complete the task successfully; if the task provokes anxiety, tension, or a bad mood, the student is more likely to abandon it early [73].

Refs. [74,75] even mention that motivation is a predictor of school performance as relevant as intelligence, and [76] add that one of the reasons why students apply themselves in tasks and learning activities, is related to the academic goals that direct their behaviors, since these are considered key predictors of performance [77].

In addition, it is expected that, as the student progresses in his studies, he will present different goals of achievement, due to his perception of the various curricular disciplines or the relevance of their contents to his vocational projects [69,71] In this sense, [77,78] concluded that students oriented towards intrinsic goals have a better academic performance, while students whose goals focus on the self, end up showing worse performance.

Consider also what [79] refer about motivation in adolescence. According to these authors, in this phase of life, motivation is evidenced by different patterns depending on the gender of the students, which influences the way they approach the tasks they face, especially in the case of the female sex, which seems to have high levels of motivation for work. Age also appears to be a variable that influences motivational patterns.

Based on the theoretical model of [80], tested by [81], ref. [70] then developed the Inventory of Academic Goals (IMA), which was adapted and validated for basic and secondary education, and for higher education teaching (IMA-ES), in order to assess students' motivation. The IMA for Basic Education and for Secondary Education consists of a self-report instrument composed of 22 questions randomly distributed over four dimensions: (1) learning-oriented goals; (2) goals aimed at avoiding social pressure in the school context; (3) goals oriented towards concrete objectives; and (4) goals aimed at avoiding social pressure in the family context. The IMA-ES also consists of a self-report instrument, this one with 17 items distributed over three dimensions: (1) learning-oriented goals; (2) goals aimed at avoiding social pressure; and (3) performance-oriented goals [82].

In this inventory, the learning goals are related to intrinsic motivation; that is, when the student learns the contents taught in order to improve their knowledge and obtain new skills and abilities. The goals aimed at avoiding social pressure result from learning with the aim of obtaining the approval of family members, teachers, or peers. Finally, performance-oriented goals are associated with the student's tendency to study only with the objective of obtaining good academic performance, that is, good grades [82].

There is unanimity on the part of the researchers with regard to the various variables that interfere with the student's academic performance, it being possible to classify them as institutional, personal and social determinants. However, it could seem evident that students with high levels of exhaustion, a greater sense of disbelief and less professional effectiveness obtain poor results in their exams [4,35,83,84] disagree with these studies and claim that burnout is not a good predictor of lower academic performance.

It is important to say that this link (not always clear) between academic performance and burnout can be justified by the use of different methods in the evaluation of performance, carried out in divergent investigations, namely, the fact that some empirical studies use the academic arithmetic mean as the sole criterion of analysis, which is notoriously insufficient [9].

Despite this, most studies are unanimous in emphasizing that burnout is negatively related to satisfaction with studies [4], professional maturity [85], the desire to abandon studies [34,86], happiness in the face of the academic path [34], and expectations of successful learning [87].

In conclusion, [9] state that the effect of burnout on academic performance is not yet fully explained, but that it appears as a relevant indicator in the decline of numerous aspects associated with performance and satisfaction with the studies themselves, as in the forecast of school dropout by the university student. In summary, the various empirical studies tend to identify that students who suffer from burnout result in poor academic performance.

2.5. Academic Burnout in the Portuguese Context: What Do the Studies Say?

With regard to Portugal, [88] carried out a study with the objective of determining the incidence of burnout in Portuguese higher education. Therefore, a questionnaire was distributed by the universities of the 20 districts of Portugal (including the universities of the archipelagos of Madeira and the Azores), through the Qualtrics platform and through the student associations of the respective institutions. This questionnaire was based on the Maslach Burnout Inventory Student Survey (MBI-SS), which will be explained below, and included 15 ordinal self-report items, whose response scale varied between "0—Never or No time" to "6—All days or Always".

According to this same study, 64.9% of the students at the University of Aveiro suffer from burnout, the highest value in all the analyzed universities; by contrast, at the Polytechnic Institute of Viana do Castelo only 15% of students suffer from burnout. Beja, Viana do Castelo, Faro, Portalegre, Vila Real, and Bragança are districts with average levels of burnout. Setúbal, Aveiro, Évora, Coimbra, Porto, Santarém, Lisbon, Viseu, Castelo Branco, Braga, and Leiria are the districts where students have the highest levels of burnout.

Ref. [88] conclude that all districts have average levels of academic involvement, with students in the Exact Sciences courses showing the lowest levels of academic involvement and the second highest burnout value among the different areas of study analyzed in the referred work (Human Sciences, Exact Sciences, Health Sciences, and Biological Sciences). In this study, Biological Sciences (at the top), the Exact Sciences and the Health Sciences are those with the highest levels of burnout. On the other hand, university students in courses in the Humanities area are those who have a greater academic involvement and those who suffer less from burnout.

The authors also concluded that female students have marginally higher values of both involvement and burnout, compared to male students.

Finally, ref. [88] point out that psychological variables, such as academic involvement and burnout, are absolutely determinant factors for the academic success of university students, being directly related to students' self-efficacy, as well as their own performance problems and school dropout.

3. Research Hypotheses

In the present research work, the following research hypotheses were defined:

- **Hypothesis 1 (H1).** *there are differences in academic burnout according to sex, with female participants having higher levels of academic burnout than male participants;*
- **Hypothesis 2 (H2).** *there are differences in academic burnout according to the age group, with students aged 18 to 25 having higher levels of burnout when compared to students aged 26 or over;*
- **Hypothesis 3 (H3).** *there are differences in academic burnout according to academic qualifications, with students in the first cycle (undergraduate) having higher levels of burnout, when compared with students from other academic degrees;*
- **Hypothesis 4 (H4).** *there are differences in academic burnout according to the area of study, with students in the areas of Biological Sciences, Exact Sciences, and Health Sciences having higher levels of academic burnout when compared to those in the Humanities area/Social;*
- **Hypothesis 5 (H5).** *there are differences in academic burnout according to the year of higher education attended, with students in the first years having higher levels of burnout when compared to students in the remaining years;*
- **Hypothesis 6 (H6).** *there are differences in the levels of academic burnout according to the arithmetic average of the course;*
- **Hypothesis 7 (H7).** *there are differences in academic burnout depending to the student's professional situation, with student workers having higher rates of burnout;*
- **Hypothesis 8 (H8).** *there is a correlation between gross monthly income and burnout, with a lower gross monthly income being associated with higher levels of burnout;*
- **Hypothesis 9 (H9).** *there are differences in academic burnout according to the participation of students in extracurricular activities, with those who do not participate in these activities more susceptible to burnout;*
- **Hypothesis 10 (H10).** *there are differences in academic burnout according to the participation of students in sports activities, with students who practice these activities showing lower levels of burnout;*
- **Hypothesis 11 (H11).** *there is a correlation between the frequency with which students practice physical exercise and burnout;*
- **Hypothesis 12 (H12).** *there are differences in academic burnout due to the students' perception (considering the particularity of their situation) about the negative impact of the sudden freedom brought on by the transition from secondary education to higher education, with students who consider that this freedom negatively affected them (while students) having higher burnout rates;*
- **Hypothesis 13 (H13).** *there are differences in academic burnout according to the reasons that led students to choose the course they are attending, and students who chose the course they attend based on the employability rate of the same show higher levels of burnout. On the other*

hand, students who choose the course by vocation and/or taste have lower levels of burnout than those who did not choose the course for the aforementioned reason;

- **Hypothesis 14 (H14).** *there is a correlation between academic burnout and the classification that students make of the course in relation to their initial expectations, and students who feel that the course did not meet their initial expectations have higher levels of burnout;*
- **Hypothesis 15 (H15).** *there is a correlation between burnout and the perception of the material conditions of the university attended, with lower levels of burnout associated with a better perception of the material conditions of the university concerned;*
- **Hypothesis 16 (H16).** *there is a correlation between burnout and the classification that students attribute to their teachers, with lower levels of burnout associated with the attribution of higher ratings;*
- **Hypothesis 17 (H17).** *there is a correlation between burnout and the classification of the relationship between students and their teachers, with lower burnout rates associated with the attribution of higher ratings;*
- **Hypothesis 18 (H18).** *there is a correlation between burnout and the classification of the relationship between students and their colleagues, with lower burnout rates associated with the attribution of higher ratings;*
- **Hypothesis 19 (H19).** *there are differences in burnout due to the uncertainty felt by students in relation to their professional future, with students who feel this uncertainty having higher levels of burnout;*
- **Hypothesis 20 (H20).** *there are differences in burnout due to the presence of a recent diagnosis of depression, with students recently diagnosed with depression having higher levels of burnout;*
- **Hypothesis 21 (H21).** *there are differences in academic burnout due to taking medication, with students taking medication having higher levels of burnout;*
- **Hypothesis 22 (H22).** *there are differences in academic burnout depending on the type of medication taken by students, and students who take antidepressants, anxiolytics, multivitamin supplements, and sleeping medication having higher levels of burnout when compared to those who do not take this medication;*
- **Hypothesis 23 (H23).** *there are differences in the levels of academic burnout according to the frequency of taking medication;*
- **Hypothesis 24 (H24).** *there are differences in the levels of academic burnout according to the reason that leads to taking medication;*
- **Hypothesis 25 (H25).** *there are differences in academic burnout due to the fact that students know (or not) colleagues who take sleeping medication, and students who do not have colleagues in this situation have higher levels of burnout;*
- **Hypothesis 26 (H26).** *there is a relationship between the arithmetic average (course grades) obtained by students and taking medication;*
- **Hypothesis 27 (H27).** *there are differences between burnout and the fact that the student has considered giving up the course or his studies, with students showing a tendency towards this dropout presenting higher levels of burnout;*
- **Hypothesis 28 (H28).** *there is a correlation between the tendency of students to consider that they can withstand the pressures in their study cycle and the presence of burnout, with students who believe they are able to withstand these pressures having lower levels of burnout;*
- **Hypothesis 29 (H29).** *there is a correlation between the classification of their academic performance and the presence of burnout, with students who manifest burnout showing a greater tendency to consider that their academic performance is inferior;*
- **Hypothesis 30 (H30).** *there are differences between academic burnout and the fact that students consider that improving some aspects of the university's functioning would help to increase their level of psychological well-being, with students considering that reducing the number of hours of daily and weekly classes, the reformulation of teaching methods, a wider range of curricular options and the availability of other means that provide psychological support would improve their psychological well-being are the students with the highest levels of burnout.*

4. Materials and Methods

We shall now present the methodology and procedures adopted in the present study.

Thus, the present work follows a quantitative data collection methodology, more precisely through the application of a questionnaire to students of the Portuguese public university in question.

The literature review on the topic was made based on a previous documentary research.

The objective of the study was to verify how many students experience academic burnout and take (or have already taken) medication due to the requirements of the academic environment.

In the first question of the questionnaire, it was questioned whether the participants studied (or not) at the analyzed public institution. If the participants did not study at that institution, they were sent to the end of the questionnaire and could not answer any more questions. Only participants who studied at the public institution analyzed could complete the entire questionnaire and were sent to the following questions.

The sample of this study is non-probabilistic and is also a convenience sample (not entirely random as the authors used their connections and networks to reach as many students as possible, in the Portuguese public university, having also been aided by various student bodies and associations, as described below); its approach was intended to provide a broad view of the academic environment in question, in order to achieve the objective of the study.

4.1. Participants

In total, 207 students from the analyzed university participated in the study, who were asked to answer a questionnaire, of which, 90% of the participants were between 18 and 25 years old and about 8% were between 26 and 35 years old, with about 31% of the participants being male and 69% female. It should also be noted that 91% of respondents were of Portuguese nationality, and 100% were resident in Portugal, with around 74% attending the university under analysis and the remaining 26% of respondents attending polytechnics at the same institution (the institution has four polytechnics). Of these students, the majority, 61%, have a first cycle (degree).

Regarding the study area, it was decided to divide the courses into four main study areas, namely, Biological Sciences, Health Sciences, Exact Sciences, and Human/Social Sciences, to facilitate the interpretation of the results by the reader, as well as the statistical analysis, and in order to meet the study carried out by [88], with whose investigation it is intended, in the end, to compare the results.

Thus, most students, about 32%, attend courses related to the area of Human/Social Sciences, 28% attend courses in the area of the Exact Sciences, 23% in the area of Biological Sciences, and about 17% are in the Health Sciences area. Most students, 29%, are in the 1st year and around 24% are in the 2nd year of higher education (in their degree). About 56% of the students have an arithmetic average of between 13 and 15.

Only 27% of the surveyed students had a paid professional occupation. Most of the students in this study, 33%, have a gross monthly income between 1000 and 1499 euros. However, about 25% have a gross monthly income between 1500 and 2499 euros and 24% have an income between 600 and 999 euros.

4.2. Data Collection Instruments

In order to understand if university students of the chosen educational institution experience academic burnout, as well as if they take (or have already taken) medication during their academic career and to identify their feelings regarding the course and the institution they attend, a questionnaire was applied to university students from a Portuguese public higher education institution. The survey consists of 55 closed-answer questions and four open-answer questions (Appendix A).

This questionnaire uses some questions from the Maslach Burnout Inventory—Student Survey (MBI-SS), adapted by [51], translated and adapted to the Portuguese language by [31]. It is a self-report scale consisting of 15 questions referring to the three subscales of academic burnout (emotional exhaustion, disbelief, and professional effectiveness) and the feelings and emotions that students experience in the school context.

Here, respondents express how often they feel what each of the 15 questions suggests, on an ordinal seven-point scale, which ranges from 0, "never" to 6, "always". The reliability of the factors was assessed by measuring the internal consistency of the Cronbach's alpha coefficient (α) and, in its entirety, the MBI-SS scale presents an $\alpha = 0.79$ [89].

Since the central point of the scale is "regularly", the total of the burnout score was calculated using the average of the questions of the three subscales, considering that the students presented burnout when this total score was higher than three, as defended by [88]. Regarding the three subscales, for the purposes of this study, questions 38 to 42 refer to the emotional exhaustion subscale, questions 43 to 46 refer to disbelief and, finally, questions 49 to 54 refer to professional effectiveness.

In the subscale dedicated to professional effectiveness, the higher the values, the lower the levels of burnout; that is, the higher the values, the lower the ineffectiveness of individuals. For this reason, the response scale for the items in this subscale has been inverted, as suggested by the study by [90] and as is done in the study by [88], a study with which we intend, in the final stretch, to compare the results of the present study. The remaining questions were elaborated from scratch, based on the consulted literature.

It should also be noted that, initially, sociodemographic information was collected through the questionnaire.

4.3. Data Collection Procedures

In the study, a questionnaire on burnout and taking medication was distributed to university students.

After elaborating the questionnaire, tests were carried out on the data collection instruments, asking education specialists to evaluate the questionnaire in terms of the time to fill it in and the clarity of the questions, and they were also asked whether or not they had learned anything useful in order to understand whether it would be necessary to make any changes to the questionnaire.

After validation and the elaboration of the necessary corrections, the associative nuclei of the various courses, sports nuclei and administrative services of the university and the polytechnics under analysis were contacted, as well as organizations created in the academic environment, in order to request the dissemination of the questionnaire to the students. The questionnaire was disseminated through social networks via the centers and services mentioned.

It should also be noted that the data collection was carried out respecting all applicable ethical principles, especially with regard to the anonymity of the respondents and the confidentiality of the investigation. There was an incentive for student participation through the drawing of tickets for the RFM SOMNII summer festival at Praia do Relógio in Figueira da Foz (a three-day general pass).

The questionnaire was online (online Google form format) since 30 March 2020 and until 30 April 2020, having obtained 207 responses, all of which valid.

4.4. Statistical Procedures

To perform the analysis of the quantitative data, the program IBM SPSS Statistics, version 25 was used. Inferential statistics were used, namely, Student's *t*-test and one-way ANOVA (parametric tests), Spearman's correlation coefficient, and the Chi-square test to test previously defined research hypotheses.

The variables were characterized using the mean and standard deviation. The level of significance was set at a value of $p < 0.05$. Regarding Spearman's Correlation Coefficient, it is also worth noting that [91] refers that correlations above 0.40 are considered strong,

while correlations that vary between 0.20 and 0.40 are considered moderate. Correlations below 0.20 are considered weak. This was precisely the criterion considered in the analysis carried out in the present investigation.

5. Results

As the values of the asymmetry (Sk = 0.219) and kurtosis (Ku = −0.522) coefficients of the burnout score are less than one, it is possible to assume that the data have an approximately normal distribution, as can be seen in Table 1. Thus, parametric tests can be used, such as Student's t-test and ANOVA [92,93].

Table 1. Descriptive analysis of the burnout score (n = 207).

Variables	*Min*	*Max*	*M*	*DP*	*Sk*	*Ku*
Burnout	0.60	4.80	2.48	0.92	0.219	−0.522

Regarding the reliability analysis, the Alfa Cronbach coefficients were calculated for the burnout score (α = 0.901) and for the respective subscales: emotional exhaustion (α = 0.929), disbelief (α = 0.916) and professional effectiveness (α = 0.830).

The values of the coefficients are above the cut-off line (0.70) and the values of the item-total correlations corrected above 0.30. It was also verified whether the output of an item improved the internal consistency of the scale (Cronbach's Alpha without the item), as suggested by [92], as shown in Table 2.

Table 2. Reliability analysis of the burnout score.

Variables	*n*	*M*	*DP*	*Cronbach's Alpha*	*No. of Items*
Burnout	207	2.48	0.92	0.901	15
Emotional exhaustion	207	2.73	1.39	0.929	5
Disbelief	207	1.91	1.31	0.916	4
Professional effectiveness	207	2.65	0.93	0.830	6

As mentioned, it was considered that students had burnout when the average score of all questions was higher than three. It is concluded that, in the total sample, 29% of the students surveyed have burnout. It is also observed that about 37% of the students are cognitively and emotionally exhausted, 17% have a cynical attitude towards their studies, colleagues and teachers, and about 36% feel incapacity and professional inefficiency.

5.1. Relationship between Burnout and Sociodemographic Variables

Student's t-test was used to verify if there were differences in academic burnout due to sociodemographic variables.

There are no statistically significant differences between men (M = 2.54; SD = 0.94) and women (M = 2.45; SD = 0.92) regarding burnout (p = 0.531). Thus, it is concluded that sex does not influence the levels of burnout.

In order to carry out this analysis, age was recoded in only two classes: from "18 to 25 years" and "26 years or more", since the respondents were concentrated in the greatest number in these age groups and to facilitate the organization of data; additionally, there are also no statistically significant differences with regard to burnout according to the age group (p = 0.156), which means that students between 18 and 25 years old do not have higher levels of burnout (M = 2.51; SD = 0.91) than students aged 26 or older (M = 2.20; SD = 1.01).

To carry out this analysis, the variable educational qualifications was recoded into two categories: "Degree" and "Other higher qualifications". With regard to educational qualifications, the differences are close to statistical significance (p = 0.065), that is, there seems to be a trend towards higher levels of burnout in undergraduate students than in

students of other study cycles. However, it cannot be considered that there are statistically significant differences between the first cycle (M = 2.57; SD = 0.96) and the academically higher study cycles (M = 2.33; SD = 0.85), in the levels of burnout.

Finally, note that there are differences in academic burnout depending on the student's professional situation, and students who do not work (M = 2.56; SD = 0.94) have higher levels of burnout (p = 0.046) than students who are student workers (M = 2.27; SD = 0.85).

5.2. Relationship between Burnout and Student Participation in Extracurricular Activities and Physical Exercise

Student's t-test was used to verify if there were differences in academic burnout due to the participation of students in extracurricular activities and due to the practice of physical exercise.

As it turns out, there are statistically significant differences in academic burnout according to the participation of students in extracurricular activities (p = 0.015). Students who do not participate in extracurricular activities have higher levels of burnout (M = 2.70; SD = 0.96) than students who participate in these activities (M = 2.37; SD = 0.89).

As far as physical exercise is concerned, there are statistically significant differences in academic burnout (p = 0.021). Students who participate in sports activities show lower levels of burnout (M = 2.42; SD = 0.87) than those who do not practice any type of physical exercise (M = 2.70; SD = 1.07).

5.3. Relationship between Burnout and the Transition from Secondary Education to Higher Education, Choice of Course, and Professional Future

Student's t-test was used to check if there were differences in academic burnout regarding the transition from secondary education to higher education and the choice of course and professional future.

In fact, there are statistically significant differences in burnout due to the students' perception of the negative impact of sudden freedom brought on by the transition from secondary education to higher education (p = 0.015). Students who consider that this freedom has affected them negatively while students have higher levels of burnout (M = 2.88; SD = 0.84) than students who consider that this aspect has not affected them negatively (M = 2.42; SD = 0.92).

In addition, there are statistically significant differences in academic burnout according to the reasons that led students to choose the course they attend. Students who chose the course they attend based on the employability rate (M = 2.49; SD = 0.86) do not have higher levels of burnout (p = 0.917) than those who did not choose this option (M = 2.47; DP = 0.95). However, students who choose the course by vocation and/or taste (M = 2.42; DP = 0.92) have lower levels of burnout (p = 0.038) than those who did not choose the course for this reason (M = 2.80; SD = 0.93).

There are also statistically significant differences in the levels of burnout according to the uncertainty felt in relation to the professional future (p = 0.004). After all, students who feel uncertain about their future work show higher levels of burnout (M = 2.56; SD = 0.93) than those who do not feel any uncertainty (M = 2.04; SD = 0.79).

5.4. Relationship between Burnout and the Existence of a Recent Diagnosis of Depression, Intake, and Type of Medication

Student's t-test was used to verify if there were differences in academic burnout due to the existence of a recent diagnosis of depression and taking medication.

Therefore, it was observed that there are statistically significant differences in burnout due to the presence of a diagnosis of depression ($p < 0.001$), since students who were recently diagnosed with depression have a higher prevalence of this syndrome (M = 3.40; SD = 0.73).

There are also statistically significant differences in academic burnout due to taking medication ($p < 0.001$), with students taking medication having higher levels of burnout (M = 2.72; SD = 0.90). Students who take antidepressants have higher levels of burnout

than those who do not take this type of medication ($p < 0.001$). In turn, students who take anxiolytics ($p < 0.001$), food supplements/multivitamins ($p = 0.024$), and sleeping medication ($p = 0.046$) have higher levels of burnout compared to those who do not take this type of medication.

In addition, there are statistically significant differences in academic burnout according to the reason for taking medication. For example, students who take medication to combat symptoms of emotional exhaustion ($p < 0.001$) and to improve their academic achievement ($p = 0.010$) have higher levels of burnout when compared to students who do not take it for these reasons.

It should also be noted that there are statistically significant differences in academic burnout due to the fact that students know (or do not know) other colleagues who take sleeping pills, since students who do not know colleagues who take this type of medication have higher levels burnout ($p = 0.021$).

5.5. Relationship between Burnout and the Tendency to Drop Out of the Course or Studies and Aspects to Improve Psychological Well-Being

Student's *t*-test was used to check if there were differences in academic burnout due to the tendency of students to drop out of the course or studies and the aspects to improve their level of psychological well-being in the school they attend.

In fact, it is noticed that there are statistically significant differences in burnout according to the fact that the student has considered giving up the course or studies, concluding that students who have considered giving up the course ($p < 0.001$) or studies ($p < 0.001$) have higher levels of burnout.

There are also differences in burnout due to the aspects that students consider that would help to improve their level of psychological well-being at the university. In fact, students who report that the reduction in the number of hours of daily and weekly classes ($p = 0.005$), the reformulation of teaching methods ($p < 0.001$), and a wider range of curricular options ($p = 0.048$) would improve their psychological well-being have higher levels of burnout.

Regarding the option concerning the availability of other means that provide psychological support to students, the differences are close to statistical significance ($p = 0.071$).

5.6. Relationship between Burnout and Study Areas, Year of Higher Education and Arithmetic Mean of Course

ANOVA was used to check if there were differences in academic burnout according to the areas of study of the students, the year of higher education they attend and their arithmetic average (grades) of their course.

There are no statistically significant differences between the study areas regarding burnout ($F = 1.379$; $p = 0.250$). In other words, the study area has no influence on burnout levels, which means that students in the areas of Biological Sciences, Exact Sciences, and Health do not have higher levels of academic burnout than the rest.

In addition, there are also no statistically significant differences in academic burnout according to the year of higher education they attend. Students in the first and last years of college do not have higher levels of burnout ($F = 0.776$; $p = 0.542$), when compared to students who attend the remaining years. In other words, the year of higher education does not influence the levels of burnout.

Regarding the arithmetic mean of course, there are statistically significant differences in academic burnout ($F = 3.369$; $p = 0.036$). Thus, students with a low average, from 10 to 12 points ($M = 2.71$; $SD = 0.98$) have higher levels of burnout than students with a higher average, from 16 to 20 points ($M = 2.22$; $SD = 0.96$). In sum, the multiple comparisons tests show that there is a trend towards a decrease in burnout levels with the increase in the arithmetic mean of the course ($p = 0.029$).

Note, however, that, for this analysis, the arithmetic mean variable of the course was recoded into three categories: "From 10 to 12 points", "From 13 to 15 points" and "From 16

to 20 points" given the classes in which the greatest number of responses were concentrated and to facilitate the organization of the data.

5.7. Relationship between Burnout and the Frequency with Which You Take Medication

ANOVA was used to check if there were differences in academic burnout depending on the frequency with which he takes medication.

There are statistically significant differences in academic burnout according to the frequency of taking medication ($F = 5.449$; $p < 0.001$). Multiple comparison tests show that students who take this type of medication about once a month or once a week have significantly higher levels of burnout than students who do not take it ($p = 0.006$).

It should be noted that in order to carry out this analysis, the variable of the frequency with which students take medication was recoded into four categories: "Only during the assessment periods", "About once a month or once a week", " I do not take any medication" and "Every day" as these are the categories in which the greatest number of responses were concentrated and to facilitate the organization of the data.

5.8. Correlation between Academic Burnout and Students' Gross Monthly Income, Frequency with Which They Practice Physical Exercise, and Their Initial Expectations Regarding the Course

Spearman's Correlation Coefficient was used to check if there was a correlation between academic burnout and the students' gross monthly income, the frequency with which they practice physical exercise, and their initial expectations in relation to the course.

In view of the data obtained, it was concluded that there is no statistically significant association between gross monthly income ($r_{sp} = -0.020$; $p = 0.776$) and burnout; that is, that a lower gross monthly income is not necessarily associated with higher burnout levels.

On the other hand, there is a weak negative correlation, statistically significant, between the frequency with which students practice physical exercise and the levels of burnout ($r_{sp} = -0.170$, $p = 0.014$); that is, the higher the frequency with which they exercise, the lesser are their burnout levels.

It can also be said that there is a moderate negative correlation, statistically significant, between the classification that students attribute to the course they entered in view of their initial expectations and academic burnout. In fact, the higher the student's initial expectations, the lower the levels of burnout ($r_{sp} = -0.267$; $p < 0.001$).

5.9. Correlation between Academic Burnout and the Perception of the University's Material Conditions, the Classification Given by Students to Teachers, and Their Relationship with Them

The Spearman Correlation Coefficient was used to check if there was a correlation regarding academic burnout due to the perception, on the part of students, of the material conditions of the university attended, as well as the burnout and the classification they attribute to their teachers and their relationship with them.

There is a weak, statistically significant negative correlation between burnout and the perception of the material conditions of the university attended; that is, when students have a perception that the material conditions of their university are superior, they suffer less from burnout ($r_{sp} = -0.137$; $p = 0.048$).

In addition, there is a moderate, statistically significant, negative correlation between burnout and the rating that students assign to their teachers ($r_{sp} = -0.349$; $p < 0.001$). It can therefore be said that students who give teachers better ratings have lower levels of burnout.

On the other hand, there is no association between burnout and the classification that students attribute to the relationship with their teachers ($r_{sp} = 0.023$; $p = 0.745$). This means that higher ratings regarding the relationship between students and teachers are not associated with lower levels of burnout.

5.10. Correlation between Academic Burnout and the Relationship of Students with Their Colleagues, the Ability to Withstand the Pressure of Studies, and the Classification of Their Performance

Spearman's Correlation Coefficient was used to check if there was a correlation regarding academic burnout and the way students classify their relationship with colleagues, their ability to withstand the pressure caused by studies and the way they classify their academic performance.

There is a weak, statistically significant negative correlation between burnout and the rating given by students to their relationship with colleagues ($r_{sp} = -0.188$; $p = 0.007$), that is, the higher the rating, the lower the levels of student burnout.

In addition, there is a strong, statistically significant negative correlation between burnout and the fact that students know (or do not know how) to withstand the pressures of their study cycle. That is, the more students think they are able to withstand the pressures of their study cycle, the lower the levels of burnout ($r_{sp} = -0.522$; $p < 0.001$).

There is also a moderate, statistically significant negative correlation between burnout and the classification of students' academic performance. This means that the lower the rating of their academic performance, the higher the levels of burnout ($r_{sp} = -0.366$; $p < 0.001$) that they suffer.

5.11. Relationship between Medication Intake and Course Arithmetic Mean

The Chi-square test was used to check if there was an association between taking medication and the course arithmetic mean (the grades of the student) (Tables 3 and 4).

Table 3. Calculation of the chi-square.

		Take Medication		Total
	Grades	**No**	**Yes**	
Average	10–12 points	28	14	42
Good	13–15 points	65	51	116
Excellent	16–20 points	33	14	47
	Total	126	79	205

Table 4. Calculation of the chi-square.

O	**E**	**O-E**	**$(O-E)^2$**	**$(O-E)^2/E$**
28	25.81	2.19	4.78	0.19
14	16.19	−2.19	4.78	0.30
65	71.30	−6.30	39.66	0.56
51	44.70	6.30	39.66	0.89
33	28.89	4.11	16.91	0.59
14	18.11	−4.11	16.91	0.93
			Total:	3.44

Degrees of freedom: 2.

Critical value from the table at the 5% level: 5.991 (which is greater than the calculated critical value 3.44).

Conclusion: there is no association between the variables. The variables are independent—there is no statistically significant relationship between the arithmetic mean of the course obtained by the students and medication intake.

6. Discussion

Among the sociodemographic variables studied, the potential effects on the burnout levels of sex (H1), age (H2), and gross monthly income (H8) were investigated based on the formulated hypotheses.

For the sample analyzed, it was not possible to attribute an influence of the gender variable to the levels of burnout. Thus, hypothesis 1 was not validated, contrary to the results of [9,88]. Note, however, that the former found only marginally higher levels of burnout in females, and that the latter attributed risk factors associated with personality characteristics to the sexes, namely, greater perceived effectiveness on the part of women, and more cynical about studies by men. Although both studies may indicate an apparent trend towards their results, the influence of sex on burnout levels does not seem clear, which was also evident in the present study. To confirm this trend, further studies would be needed, with larger and standardized samples.

Additionally, the age of the students did not reveal any influence on the burnout levels, although the literature refers that one of the groups most affected by the syndrome is the millennials [94]. In this study, higher levels of burnout were not found among students aged 18 to 25 years, when compared with those of students aged 26 or older, so research hypothesis 2 was not validated. Remember that the definition of millennial is not consensual, so the age range considered in this study may not be representative of that generation. On the other hand, the entire sample consisted of university students and, regardless of the age range referring to millenials, not all will be university students, so it would be necessary to extend the study universe to extra-university realities in order to be able to correctly measure the levels of the generation as a whole.

According to the research hypothesis 8, it was expected that lower gross monthly income would be associated with higher levels of burnout, as suggested by [33], who emphasize that the lack of financial support is a variable associated with academic burnout. Studies such as those by [32] point to the fact that the related social and professional pressures with higher education funding being a factor that makes university students more vulnerable to academic burnout. However, this was not verified in this study, since a lower gross monthly income was not significantly associated with higher levels of burnout; thus, not validating hypothesis 8. The financial support that the University in analysis provides and the fact that it is located in a geographical area where the cost of living is not high can explain this result.

With regard to academic variables, the educational qualifications (H3), the study areas (H4), the year of higher education attended (H5), the arithmetic average of the course (H6) and the professional situation were considered for analysis (H7).

No significant differences were found in the burnout syndrome between educational qualifications, areas of study or year of higher education attended; therefore, hypotheses 3, 4, and 5 were not validated. The fact that there are no significant differences in relation to educational qualifications and the year in higher education can be explained by the possible uniformity of academic load throughout the university course; that is, students continue with the same workload and suffer from stress throughout the course. As it turned out, in the course of their training, it is understood that students are, on the one hand, reformulating their goals, and, on the other, being confronted with the reality of their course and the profession they intend to exercise as mentioned by the authors [69,71,95]. These perceptions that are being fed may lead students to continually renew the pressure on themselves, or that, on the contrary, they will gradually lose their motivation and enthusiasm for the path they have been following. In any case, stress levels can be replenished and thus maintained, for different reasons, throughout the course.

Ref. [88] found that students of courses in the area of Biological and Exact Sciences are the ones who reveal the highest levels of burnout among the various areas of study and that those in the Humanities are those who suffer less from burnout; this was not evidenced by the present study. This result can be explained by the distribution of the study areas in the sample, it being verified that the majority of respondents, about 32%, were studying in the area of Human/Social Sciences, 28% in the area of Exact Sciences, around 17% in the area of Health Sciences and the remaining 23% were in areas related to Biological Sciences. In the study by [88], 33% attended courses in the Humanities area, about 30% in the Exact Sciences area, 27% in the Health Sciences area, and only about 10%

in the Biological Sciences area. The main differences in the two distributions are, therefore, in the areas of Health Sciences and Biological Sciences; that is, in the present study there was an excess of 13% of students in the area of Biological Sciences and 10% less in the area of Health Sciences.

As for the arithmetic mean, it was found that students with a lower average, from 10 to 12 points, have higher levels of burnout than students with higher averages, from 16 to 20 points. This result validates hypothesis 6 and is in line with what is reported by the authors [45,46], who indicate that the syndrome is related to poor cognitive performance and decreased academic achievement. It is understandable that this is the case, since academic burnout, as we have seen, is characterized precisely by a lack of motivation to study and perform the required tasks, in addition to physical symptoms such as constant tiredness and fatigue and migraines, thus impacting the output of students who suffer from it.

The influence on burnout levels was also analyzed according to the professional situation, verifying that students who do not work have higher levels of burnout than those who are worker-students. Thus, hypothesis 7 has not been validated. It would be plausible to consider that student workers could have higher levels of burnout, compared to students who do not engage in any paid professional activity, because they have to reconcile their studies with their profession, and are therefore faced with more challenges. However, according to the results obtained in the present study, and since no references to similar analyses were found in the revised literature, the possibility of students with worker-student status having better developed or adapted mechanisms such as coping and emotional intelligence, managing to better manage stress in relation to students who have less challenges to manage.

In addition to the sociodemographic and academic variables analyzed above, we tried to understand the impact that students' perceptions about the transition from secondary to higher education, and their options regarding the course, can have on the level of burnout, considering that the transition experience is an imminent cause of stress during the first year of post-secondary studies [28]. In fact, it was proven that there are differences in the manifestations of academic burnout due to the students' perception about the negative impact of the sudden freedom brought by the transition from secondary education to higher education, thus validating hypothesis 12. Students who consider that this freedom has affected them in a negative way have higher levels of burnout, as [28] refer. Freedom brings responsibility and, in this sense, young people may not yet be mature enough to properly manage emotions, relationships and even studies, without a support network as tight as up until then; that is, there are lower levels of emotional intelligence and resilience that, as mentioned earlier, act as a kind of protection against the syndrome.

The conditions of the educational institution itself are also pointed out in the literature as factors related to the burnout syndrome [9,10,33]. It was found, in the present investigation, that students who have a perception that the material conditions of their university are superior suffer less from burnout. Additionally, the higher (better) the relationship with their colleagues, the lower the burnout levels of students. Thus, hypotheses 15 and 18 were validated, which is in agreement with the conclusions of [36], regarding the contribution to the appearance of burnout of factors such as reduced solidarity and companionship, competition and disagreements with colleagues. However, higher classifications regarding the relationship between students and teachers were not, in this study, associated with lower levels of burnout, contrary to what was indicated by the authors [36], who report that poor relationships between students and teachers and the lack of feedback from teachers, are academic social risk factors that can precede or predict the appearance of burnout. Therefore, hypothesis 17 was not validated.

Another factor that is pointed out in the literature as a predictor of academic burnout felt by students is the competence of their teachers [96]. Further, in the present study, it was concluded that students who attribute better ratings to their teachers show lower levels of burnout, which validates hypothesis 16. Students who feel that teachers are not

competent may tend to develop a more cynical attitude towards the course, and/or become discouraged, feeling that the discipline or course does not meet expectations, which, in turn, may influence your motivation and commitment to studies. Students who are unmotivated and with worse academic performance are more susceptible to developing the syndrome.

The impact that the reasons for choosing the course can have on the levels of burnout was also analyzed, concluding that the students who chose the course they attend taking into account the employability rate do not present significantly higher levels of burnout than those for which the choice did not consider this criterion. However, students who chose the course by vocation and/or taste have lower burnout levels than those who did not choose the course they are attending for that reason. Therefore, hypothesis 13 was partially validated, and the assumption that the vocation or taste for the course may be linked to greater motivation on the part of the students, and thus constitute a protective factor against this syndrome as mentioned in the literature seems plausible. Remember that [95] affirm that the choice of the profession to be exercised is not fully conscious, ending up not being a factor directly linked to the students' decision. Factors which do weigh, the authors point out, for example, are economic reasons, reputation or the desire to help others.

In the present study, the correlation between burnout and the fact that students feel they know (or not) how to withstand the pressures of their study cycle was also assessed. The more students think they are able to withstand the pressures of their study cycle, the lower their burnout levels. In addition, students who report that the reduction in the number of hours of daily and weekly classes, the reformulation of teaching methods and a wider range of curricular options as factors that would improve their psychological well-being, in the university context, present greater burnout levels. Hypotheses 28 and 30 have therefore been validated.

Ref. [96] refer to the low expectations of students with regard to their course as one of the factors that most result in burnout in Portuguese university students. Ref. [95] state that, by understanding, during their academic career, that the course or future profession does not meet the expectations created, the student develops a sense of disappointment that, consequently, can also lead to frustration, discontent and stress, with a tendency to increase continuously, and lead to a burnout scenario. If the scenario gets worse, and if effective coping strategies and their implementation are neglected, a burnout scenario will most likely arise. Similar results were obtained in the present study, since it was concluded that the higher the initial expectations of the student, the lower the levels of burnout, therefore hypothesis 14 was validated.

Issues related to employability and the perception of the absence of offers in the labor market were also pointed out as factors that generate stress and anxiety in modern society and associated with academic burnout [6,33]. The present study also found that students who feel uncertain about their future work show higher levels of burnout than those who do not manifest this uncertainty, thus validating hypothesis 19. This uncertainty felt by students may be partly explained by the crisis that we are facing, as a result of the COVID-19 pandemic, namely, regarding its repercussions in the labor market, in which it was already difficult for graduates to enter.

In Portugal, young people have more and more academic training, according to the data in [97], which show that, in 2019, there were 83,193 individuals with recent degrees (students who completed their bachelor's, master's, doctorate, or specialization course in that year). In Portuguese society, until the 1980s, having a higher education was associated with ensuring a well-paid job. However, the widespread entry into higher education and the resulting increase in graduated individuals caused significant changes in this scenario. Portugal has a small and diversified economy, there is little labor, and this reality, combined with constant advances in technology and automation, contributes to the difficulty of finding jobs by young people. Most young people are unable to obtain employment in their area of training, or if they do, it is poorly paid. Nowadays, the number of young people who have a regular full-time job is decreasing, and those who have it are hardly able to achieve

a degree of security in the long term; that is, a large part survives through occasional jobs in the short term (part-time), with little or no guarantees and contractual rights, which results in the possibility of losing jobs unexpectedly due to economic crises and/or the employer (being fired with no forewarning). These situations provoke feelings of insecurity, uncertainty and fear in this generation, with serious psychological consequences. Due to the social and economic aspects mentioned, most young people postpone the decisions and responsibilities inherent in adult life, remaining for long periods semi-dependent on their parents, with all the social and personal repercussions that arise from it [98]. According to [99], the youth unemployment rate in the European Union increased by two percentage points between 2019 and 2020, reaching 17%.

Other factors considered important in preventing burnout are extracurricular activities and physical exercise. This study points in this direction, since it was concluded that students who participate in extracurricular activities or practice physical exercise have lower levels of burnout, and, in addition, the greater the frequency with which they practice physical exercise, the lower these levels are. These results allow us to validate the research hypotheses 9, 10 and 11, and are congruent with those obtained by [36], who showed that non-participation in cultural or recreational activities can precede or predict the appearance of burnout.

As already mentioned, burnout syndrome is related to depressive symptoms [47] and even suicidal thoughts [13]. The analysis of the data in the present study showed that students who were recently diagnosed with depression have higher levels of burnout, so hypothesis 20 was validated.

The need to take medication was pointed out by [96] as a predictor of academic burnout experienced by university students. In the present study, it was found that students who take medication show higher levels of burnout, and those who take it about once a month or once a week have significantly higher levels of burnout than students who do not take any medication. Regarding the type of medication, those who take antidepressants have higher levels of burnout than those who do not; those who take anxiolytics or sleeping medication, or food supplements/multivitamins, have higher levels of burnout compared to those who do not take this type of medication. In this study, it was also determined that students who take medication to combat the symptoms of emotional exhaustion (related to burnout) and to improve their academic performance have higher levels of burnout when compared to students who do not take it for these reasons. Thus, research hypotheses 21, 22, 23, and 24 were validated. This result can be justified by the social pressure that is exerted by society and by family members (related to the desire that the students conclude their study cycles successfully), and also by the increasing responsibility [3], economic pressures, cultural, and even aspects related to the students' personality [4]. It would be pertinent to understand if the levels of burnout are higher in students who take more than one type of medication at the same time.

It should also be noted that students who do not know other colleagues who take sleeping medication have been shown to have higher levels of burnout, which validates hypothesis 25. A possible explanation for these results may be the fact that difficulty in sleeping and/or the medication taken are felt as taboo topics, and not knowing specific coping strategies via such medication may be detrimental (given the importance of a good night's sleep).

Note, however, that no relationship was found between the arithmetic mean obtained by students and taking medication. Therefore, hypothesis 26 has not been validated. Considering, as indicated above, that taking medication can be enhanced by the social pressure exerted, this result can be justified by the idea that this pressure is exerted on students whatever their course average; that is, if the student has a lower average, you will feel pressure to go up; if it is average, you may be required to improve it to reach the highest level; if it is already high, you will feel pressure to maintain it.

Ref. [96] point out the student's subjective academic performance and the intention to give up his study cycle as relevant predictive factors for the academic burnout felt by

students. In this sense, it was found, in the present study, that students who consider giving up the course or studies have higher levels of burnout, and therefore hypothesis 27 was validated. Regarding the classification of their academic performance, it was proved that the better they classify their academic performance, the lower the burnout levels of the students, which validates the hypothesis 29.

Finally, hypothesis 30 was also validated. There are differences between academic burnout and the fact that students consider that improving some aspects of the university's functioning would help to increase their level of psychological well-being, with students considering that reducing the number of hours of daily and weekly classes, the reformulation of teaching methods, a wider range of curricular options, and the availability of other means that provide psychological support would improve their psychological well-being are the students who have higher levels of burnout.

7. Conclusions

Based on the results obtained, it was not possible to establish a relationship between the occurrence of burnout and sociodemographic variables, such as gender, age group, and gross monthly income, or academic variables, such as educational qualifications, areas of study, year in higher education, and the relationship with teachers.

However, there are statistically significant differences between burnout and the following factors: the arithmetic mean of the students' course; your professional situation; the way they perceive the transition to higher education; the material conditions of the educational institution; their assessment of their relationship with colleagues; the rating they attribute to the competence of teachers; the reasons for choosing the course; students' ability to withstand the pressure of their study cycle; the aspects that they believe can improve their level of psychological well-being at the university; your expectations regarding the course; uncertainty regarding the professional future; their participation in extracurricular activities; the practice of physical exercise (and the frequency of this practice); a recent depressive clinical condition; taking medication (in particular antidepressants, anxiolytics, multivitamins and/or hypnotics) and the frequency with which they take it; the reason for taking medication (alleviating symptoms of emotional exhaustion and improving school performance); the knowledge of colleagues who take sleeping medication; consider giving up the course or studies; and the way they rate their own academic performance.

In contrast, among the factors that seem to protect students from experiencing burnout are academic involvement, intrinsic motivation, coping strategies and social support, emotional intelligence, and resilience.

It should be noted that the present study showed that about 29% of the university students at the analyzed university show signs of burnout. Higher education institutions urgently need to take measures to remedy this situation, which constitutes a serious public health problem and which has several consequences, namely that of hampering the training of young people. Among these measures, rethinking, and reformulating teaching will be essential.

The results obtained provide an important practical contribution to the management of the satisfaction of university students and to improve their quality of life, since they alert to several factors that can serve as a basis for correcting failures and implementing improvements, increasing permanence and success in the analyzed higher education institution and, potentially, in other institutions.

In terms of practical contribution, it is suggested that the educational institution analyzed and the other higher education institutions implement some of the suggestions listed below to increase student satisfaction and students' quality of life:

- Reformulation of teaching methods, creating new methods of assessment (not just exams and/or tests) and promoting dynamic classes to stimulate students' creativity and motivation (taking, for example, occasional classes outdoors or with music);
- The reduction in the number of hours of daily and weekly classes; Portugal is one of the European countries where students have a greater number of hours, on average,

about 21 h of classes per week (similar to Poland). The European average is only 17 h. However, there are countries in the North where these numbers are lower, for example, in Sweden (10 h) and/or Norway (13 h). However, if study time is added to this time, a national university student spends, on average, about 46 h in class and in study. Regarding worker-students, the number rises to the 63 h per week that worker-students occupy between classes, study, and their profession, which justifies that it is very hard to work and study simultaneously in such a national context [100];

- Provide a wider range of curriculum options so that students can study what they really like, and think is appropriate for their vocational pathways;
- Providing more free workshops to learn how to deal with anxiety, pressure, stress, time management, as well as sessions on emotional intelligence and resilience aimed at the entire academic community;
- Reduction of waiting lists for psychology appointments;
- Greater dissemination of mental illness and psychology consultations;
- Make the exam schedule available at the beginning of the semester, so that students can choose the assessment method in an organized manner and reduce students' stress and anxiety during the assessment period;
- Greater coordination by the university's Rectory to avoid accumulating exams on the same day;
- Have a lower load of group work and, on the other hand, more individual work, since it was an aspect mentioned by the students;
- The reduction in the number of students per class in order to promote greater teacher–student interaction;
- Reformulation of the program of most curricular units, giving more importance to the practical aspect of teaching, the promotion of short-term paid internships and, in general, the preparation of students for the imperfections of the working world (which is the main mission of teaching at university). In the same sense, the courses could be divided into two phases: one held at the university and the other at a company (having access to real problems), with the company paying students for their time, knowledge and availability or, alternatively, paying for their tuition fees (as occurs in Germany). This measure would increase the students' intrinsic motivation, which, as verified in the present study, is a burnout protection factor;
- Consideration of student feedback regarding the topics taught and the topics not taught that may be really relevant to them;
- Creation of an extracurricular physical exercise activity to promote individual and team work to relieve stress and promote interpersonal relationships;
- Improving the comfort of leisure spaces and increasing the number of social spaces to relieve stress and promote interpersonal relationships;
- Improving material conditions to increase comfort in classrooms, as material conditions have an influence on burnout;
- Individual and group orientation programs as suggested by the authors [57];
- If the success of higher education institutions and their students is related to the well-being of teachers, it is crucial to analyze the predominance of stress and burnout in this profession to understand the problems and some of the causes behind stress and implement measures [101].

In short, future research may relate the variables burnout and taking medication with others not addressed in this study, such as student personality traits (anxiety, rigidity, perfectionism, and self-efficacy), the social support system in which he/she is inserted, and the coping strategies used by him/her.

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Appendix A. Online Questionnaire (Google Forms) Distributed to University Students at the Portuguese Public University

Burnout is a state of physical and mental exhaustion caused by professional/academic life.

This questionnaire was carried out with the aim of analyzing whether university students have experienced, at some point in their academic life, the burnout syndrome. It also serves to understand whether these same students took (or still take) any medication during their academic career and, if so, what motivated them or motivates them to do so.

Your data will be treated confidentially, being used for scientific purposes only.

This questionnaire is anonymous.

* Required

1. Are you a student at the Portuguese public university? *

☐ Yes
☐ No

2. Gender *

☐ Female
☐ Male

3. Age *

☐ 18–25
☐ 26–35
☐ 36–45
☐ 46–55
☐ Other: _____

4. Country of origin (place of birth): * _____

5. Country of residence: * _____

6. What is your educational establishment? *

☐ Portuguese public university
☐ Polytechnic 1 of the Portuguese public university
☐ Polytechnic 2 of the Portuguese public university
☐ Polytechnic 3 of the Portuguese public university
☐ Polytechnic 4 of the Portuguese public university

7. What are your educational qualifications? *

☐ Degree
☐ Master
☐ PhD
☐ Postdoctoral
☐ Aggregation

8. What is your area of study? *

☐ Public Administration
☐ Biology
☐ Biochemistry
☐ Biotechnology
☐ Materials Science and Engineering
☐ Biomedical Sciences
☐ Engineering Sciences
☐ Health Sciences
☐ Marine Sciences
☐ Environmental Sciences and Engineering
☐ Communication Sciences and Technologies
☐ Social Sciences
☐ Accounting
☐ Design
☐ Economy
☐ Education
☐ Electrotechnical
☐ Biomedical Engineering
☐ Civil Engineering
☐ Computer Engineering
☐ Engineering and Industrial Management
☐ Mechanical Engineering
☐ Chemistry
☐ Chemical Engineering
☐ Physics
☐ Geosciences
☐ Management
☐ Computers
☐ Languages
☐ Mathematics
☐ Music
☐ Regional and Urban Planning
☐ Psychology
☐ Chemistry
☐ Translation
☐ Tourism
☐ Other: _____

9. What year of higher education do you attend? *

☐ 1st year
☐ 2nd year
☐ 3rd year
☐ 4th year
☐ 5th year

10. Currently, what is your average course? *

☐ 10–12
☐ 13–15
☐ 16–18
☐ 19–20
☐ Other: _____

11. Do you have any paid work? *

☐ Yes
☐ No

12. What is the gross monthly income of your household (in euros)? *

☐ Less than 600 euros
☐ € 600–€ 999
☐ € 1000–€ 1499
☐ € 1500–€ 2499
☐ € 2500–€ 3499
☐ € 3500–€ 4499
☐ € 4500–€ 5499
☐ € 5500–€ 6499
☐ More than € 6500

13. Who do you live with? *

☐ Alone
☐ Parents
☐ Grandparents
☐ Other family members
☐ Other: _____

14. Who mainly finances your studies? *

☐ Parents and/or other family members
☐ Himself
☐ Scholarship and/or other social support
☐ Other: _____

15. Do you participate in extracurricular activities? *

☐ Yes
☐ No

16. What are the extracurricular activities in which you participate? *

Check all that apply
☐ Associations
☐ Academic Tuna
☐ Academic Practice and other related activities
☐ Events organized by the university
☐ I do not participate in extracurricular activities
☐ Other: _____

17. Do you consider that the fact of participating in many extracurricular activities negatively affects your studies? *

☐ Yes
☐ No

18. Do you practice physical exercise? *

☐ Yes
☐ No

19. How often do you exercise? *

☐ Once a month
☐ Once a week
☐ Two to three times a week
☐ Every day
☐ I don't practice physical activity

20. Do you consider that, in the transition from secondary education to higher education, most students gain more freedom in a relatively sudden way? *

☐ Yes
☐ No

21. Do you consider that this freedom affected you negatively, as a student? *

☐ Yes
☐ No

22. What are the reasons that led you to choose the course you are attending? *

Check all that apply
☐ Social pressure
☐ Employability rate
☐ Pressure from family and/or friends
☐ Vocation and/or taste
☐ Other: _____

23. In relation to your initial expectations, how would you rate the course you are attending? *

☐ Worse
☐ Like
☐ Better

24. In general, how do you rate the material conditions of the university you attend? *

☐ More
☐ Reasonable
☐ Good
☐ Excellent

25. In general, how do you rate your teachers? *

☐ Incompetent
☐ Reasonable
☐ Good
☐ Excellent

26. How do you rate your relationship with most of your teachers? *

☐ Bad
☐ Fair
☐ Good
☐ Excellent

27. And how do you rate your relationship with your colleagues? *

☐ Bad
☐ Fair
☐ Good
☐ Excellent

28. Do you feel uncertain about your professional future? *

☐ Yes
☐ No

29. Have you recently been diagnosed with depression due to the demands of your studies? *

☐ Yes
☐ No

30. Have you ever needed to take medication in order to meet the demands of your studies? *

☐ Yes
☐ No

31. What medications did you take/take? *

Check all that apply
☐ Antidepressants
☐ Anxiolytics (medicines for anxiety)
☐ Food supplements/multivitamins to improve your mental performance (that is, to improve your memory and concentration), increase your energy and, consequently, improve your academic results
☐ "Smart drug" (Piracetam)
☐ Creatine
☐ Stimulants (for example, Adderall or Ritalin)
☐ Sleep medications (for example, Diazepam, Estazolam, Alprazolam and Zolpidem)
☐ I never took any medication during my studies
☐ Other: _____

32. How often do you take/took these medications? *

☐ Every day
☐ About once a month
☐ About once a week
☐ Only during evaluation periods
☐ I don't take any medication
☐ Other: _____

33. Why are you taking/taking this medication? *

Check all that apply
☐ Social pressure
☐ Symptoms of emotional exhaustion
☐ Influence of friends and/or family
☐ To improve my academic achievement
☐ By medical prescription
☐ I don't take any medication
☐ Other: _____

34. Have you ever experienced side effects like: *

Check all that apply
☐ Gastrointestinal disorders
☐ Allergies
☐ Buzzing
☐ Palpitations
☐ Convulsions or confusional states
☐ Excessive drowsiness
☐ Withdrawal syndrome, which causes tremors, psychomotor agitation, sweating, palpitations, nausea and vomiting, disorientation, hallucinations and even seizures
☐ Decreased attention, reaction time and performance speed
☐ Confusion and motor incoordination
☐ I didn't feel any side effects
☐ I don't take any medication

35. Do you know any colleagues who have taken/take dietary supplements/multivitamins to improve their mental performance (memory and concentration), increase their energy and, consequently, improve their academic results? *

☐ Yes
☐ No

36. Do you know any colleagues who have taken/take stimulants, such as Adderall or Ritalin? *

☐ Yes
☐ No

37. Do you know any colleagues who have taken/take sleeping pills, such as Diazepam, Estazolam, Alprazolam or Zolpidem? *

☐ Yes
☐ No

Emotional exhaustion *
In the next questions, choose the frequency with which, throughout your academic career, you encounter/have encountered the feelings described.

	Never	Almost Never	Sometimes	Regularly	Enough Times	Often	Ever
38. My studies leave me emotionally exhausted.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
39. I feel exhausted at the end of a day of classes at the university.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
40. I feel tired when I get up in the morning and think I have to face another day at the university.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
41. Attending a class and/or studying makes me tense.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
42. My studies leave me completely exhausted.	⬭	⬭	⬭	⬭	⬭	⬭	⬭

Disbelief *

In the next questions, choose the frequency with which, throughout your academic career, you encounter/have encountered the feelings described.

	Never	Almost Never	Sometimes	Regularly	Enough Times	Often	Ever
43. I have been losing interest in my studies since I entered university.	◯	◯	◯	◯	◯	◯	◯
44. I feel unenthusiastic about my studies.	◯	◯	◯	◯	◯	◯	◯
45. I believe less and less in the potential usefulness of my studies.	◯	◯	◯	◯	◯	◯	◯
46. I have doubts about the meaning of my studies.	◯	◯	◯	◯	◯	◯	◯

47. Have you thought about giving up the course you are attending? *

☐ Yes
☐ No

48. Have you thought about giving up your studies? *

☐ Yes
☐ No

Professional effectiveness *

In the next questions, choose the frequency with which, throughout your academic career, you encounter/have encountered the feelings described.

	Never	Almost Never	Sometimes	Regularly	Enough Times	Often	Ever
49. I can effectively solve the problems that I face in my studies.	◯	◯	◯	◯	◯	◯	◯
50. I believe that I participate, in a positive way, in the classes I attend.	◯	◯	◯	◯	◯	◯	◯
51. I feel like I'm a good student.	◯	◯	◯	◯	◯	◯	◯
52. I feel stimulated when I reach my school goals.	◯	◯	◯	◯	◯	◯	◯
53. I have acquired knowledge in many relevant subjects during my course.	◯	◯	◯	◯	◯	◯	◯
54. During classes, I feel that I can follow the material effectively.	◯	◯	◯	◯	◯	◯	◯

Global Assessment *

55. From 1 to 5, how do you rate your posture in relation to the following statement: "I can handle the pressures I feel very well in my study cycle." *

Strongly disagree ☐ ☐ ☐ ☐ ☐ Strongly agree

56. How do you rate your performance on the course? *

☐ Bad
☐ Fair
☐ Good
☐ Excellent

57. Which of the following do you think would help to improve your level of psychological well-being at the university? *
Check all that apply

☐ Reduction in the number of hours of daily and weekly classes
☐ Reformulation of teaching methods
☐ More opportunities (resource or second "calls") so that students can pass each of the course units
☐ A wider range of curriculum options
☐ Organization of more workshops to teach ways to reduce stress and anxiety
☐ Provision of other means to provide psychological support to students
☐ Other: _____

58. Describe what, in your opinion, could help improve your level of psychological and physical well-being at the university. *

_____
_____
_____

59. E-mail for contact (in case of winning the draw). _____

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Article

A Study of the Emotional Intelligence and Personality Traits of University Finance Students

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Abstract: Studies on financial behavior indicate that emotional intelligence (EI) and personality traits (PTs) explain much of the bias in financial activity. This study aims to identify in which dimensions of theEI and PTs of university students in finance further training is needed to avoid financial behavior bias. To this end, the EI and PT levels of a sample of university finance students and financial industry professionals were compared using the Trait Emotional Intelligence Questionnaire (TEIQue) and Big Five Inventory questionnaire. Subsequently, the dimensions of EI and PTs in which students have a deficit compared to professionals were identified, and the impacts that this deficit causes on the financial behavior of students were determined. The results indicate that students are deficient in the EI competencies related to empathy, emotion regulation, self-motivation, stress management, optimism, and self-esteem. Furthermore, PTs are related to kindness, awareness, openness, and extraversion. This deficit makes students more likely to have financial behavior biases such as risk tolerance, endowment, optimism, self-control, and loss aversion. These findings suggest that universities should be aware of providing financial students with full training in EI and PTs to help them successfully address their professional future.

Keywords: financial education; emotional intelligence; personality traits; financial behavior; university students

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1. Introduction

Studies on financial behavior address a combination of psychological, sociological, and economic concepts to explain what happens in the real economy, in which economic agents present limitations to the exercise of rationality [1,2]. In this regard, various criteria have been used to try to explain the factors that cause biases in financial behavior, highlighting among the most recent ones emotional intelligence (EI) and personality traits (PTs). On the one hand, high levels of EI have been shown to lead to superior employee performance [3–5] and the better financial performance of employees [6]. On the other hand, investor decisions and portfolio performance have also been found to be directly related to PTs [7,8].

For university students, the previous literature on financial behavior shows incipient and controversial results. For example, Haigh and List [9] found that professionals may have stronger financial behavior biases than non-professionals. However, other studies indicate that students have lower EI levels than professionals. Scott-Halsell, Shumate, and Blum [10] concluded that students did not have a sufficient level of EI to be successful leaders, and Scott-Halsell, Blum, and Huffman [11] concluded that there are significant differences between professionals and university students in all areas of EI.

The conclusions obtained from the previous literature indicate that the levels of EI and PTs can influence the financial decisions of both students and professionals, but that these conclusions are still initial and remain controversial regarding the differences

that students and professionals can present. It may be that this controversy is due to data on the psychological influences on financial behavior not being well addressed in student populations [12]. Therefore, it is necessary to understand the abilities and skills of finance students because of their effects on financial behavior will have an important impact on their future personal well-being [13]. Likewise, EI and PTs explain a person's professional achievements, as high reflective skills coupled with high levels of EI are a decisive comparative advantage. However, the understanding of individual determinants of financial success may still be incomplete [14]. The research questions are, then, the following: Is there a difference in EI and PT levels between university finance students and financial industry professionals? If there is, could it cause students to have more financial behavior biases? If differences appear and are related to financial behavior biases, the curricula could incorporate training strategies in EI and PTs with the aim that students begin their careers in the financial industry with the highest levels of non-cognitive skills required to be successful.

To resolve the research questions, EI and PTs were measured from a sample of university students and professionals from the financial industry, confirming the differences between the two samples. These differences between students and professionals were then associated with different biases in financial behavior, which allowed us to determine which aspects of the EI and PTs of students should be used to improve their professional training. From the above, the present work is structured as follows. After this Introduction, a review of the literature is made that relates EI and PTs to the financial behavior of university students. The sample and analysis tools used for the investigation are detailed below. Finally, the results and main conclusions are presented.

2. Literature Review

The previous literature on financial behavior has developed different lines of research over time. Initially, financial behavior has been approached from a global perspective, with a descriptive analysis of the different biases in financial behavior [15]. Subsequently, it has tried to find solutions to these biases through two scientific criteria, one of them around the theory of emotions [16–18] and another according to the PTs [2,19–23]. The following is an analysis of the main conclusions obtained by the previous literature on financial behavior forEI, PTs, and university students.

2.1. Emotions and Financial Behavior

So far, only a limited number of studies have linked personality psychology and financial behavior. Typically, the main source of inspiration for financial behavior has been cognitive psychology, which offers a broad set of ideas about human decision-making and about the biases that tend to influence decision-making processes [24]. Cognitive psychology proposes that people act based on situations they already know and the interpretation they give them [25]. In the context of this cognitive theory, cognitive biases are defined as those rules that help the individual to simplify complex situations to be able to adopt models of decisions, and convenient actions are identified [26]. Pompian [27] classified biases into two categories: cognitive biases, which involve how people think, and emotional biases, which involve how they feel. For their part, cognitive biases arise from errors in memory and information processing from faulty reasoning, while emotional biases lead to reasoning influenced by feelings. In the area of financial behavior, Pompian [17] points out that investors are subconsciously influenced by past experiences and personal beliefs to the extent that even smart investors can deviate from logic and reason. He considers that EI is related to different biases such as trust in their gut, status quo, loss aversion, self-control, endowment, regret aversion, and affinity. He also identified anchoring bias, associating it with unsophisticated investors who are especially driven by emotional biases that lead them to be especially risk averse.

Munir et al. [18] concluded that people who have control over their emotions can make better investment decisions than those with lower EI, finding a positive and significant

relationship between EI and financial behavior. Ezadinea, Fathi, and Salami [28] also demonstrated the effects of EI on financial behavior biases and investment performance. Pirayesh [29] carried out an empirical study from which it was concluded that there was a relationship between global EI and the investors' decision, pointing out that investors with a high level of EI had a greater riskaversion, understood as mistrust that the individual manifests to accept an offer with an uncertain result compared to another offer with a less profitable but safer result [30]. On the other hand, Tanvir, Sufyan, and Ahsan [31] used Goleman's (1998) five dimensions of EI and demonstrated that there was an influence of global EI and some emotional competencies (emotion regulation, self-motivation, and trait empathy) in the investor decision-making process. Likewise, Dhiman and Raheja [32] stated that individuals who have high values of emotional competencies, emotion regulation, stress management, self-esteem, self-motivation, relationship, and sociability, have a higher level of risk tolerance. In this sense, risk tolerance refers to the amount of risk that the individual is willing to take to obtain a reward [17,33].

2.2. PT and Financial Behavior

Van Witteloostuijn and Muehlfeld [34], based on personal psychology and cognitive psychology, concluded that the personality of a human being is a key determinant of his/her performance and behavior, and that contributes to explaining the differences between individuals in terms of susceptibility to financial behavioral biases. From this perspective, an individual's financial decision process is based on a complex combination of demographics and personal characteristics [35]. Demographics include aspects such as age, gender, income, and level of education [36,37], and personal characteristics refer to personality traits, values, and emotions [38,39]. Furthermore, Tauni, Fang, and Yousaf [22] investigated the association between information acquisition and financial behavior by analyzing the influence of the investor's personality. The results of their study indicated that the acquisition of information is directly proportional to the frequency of trading.

Salovey [40] found that there are some PTs, such as extraversion, agreeableness, neuroticism, openness, and responsibility, that can systematically influence investment decisions. Durand, Newby, and Sanghani [7] also demonstrated that investment decisions and portfolio performance are directly related to extraversion, agreeableness, neuroticism, openness, and conscientiousness. Hopfensitz and Wranik [41] associated a greater tendency to yield to risk aversion with high levels of neuroticism. Dhiman and Raheja [32] affirmed that individuals who have high values of extraversion, agreeableness, and openness also have a higher level of risk tolerance. For their part, Durand et al. [21] proposed that investor confidence is associated with PT in two heuristics used to model market movements, that of availability (strategy of estimating the probability of an event occurring through associations that come to mind) and disposition (a tendency to disproportionately hold assets with monetary loss while simultaneously liquidating assets and accrued gains). Other studies have corroborated that financial advice is more likely to increase the frequency of trading when the adviser's personality tends to be frank, conscientious, and personable and that information obtained from financial advisors causes less adjustment in investor portfolios when her/his personality is extraverted and neurotic [42,43]. Furthermore, higher levels of openness could favor investment behaviors in changing markets because new information is more likely to be integrated into decision-making, that is investors with a high level of openness invest less in bad markets because they have greater control over risk averse bias [41].

2.3. The Financial Behavior of University Students

Previous studies suggested that EI is an important aspect of academic achievement and student retention [44]. Furthermore, there is a positive relationship between self-control and the employability potential of students [45]. The financial profile of young people of the millennial generation is often characterized by low financial literacy, risky financial behavior, and poor financial satisfaction [46,47]. Due to these generational changes, many

experts consider that a change in the financial education system that affects interpersonal skills such as planning capacity, the confidence to be proactive, and the willingness to take investment risks is also necessary [48,49]. Falahati et al. [13] pointed out that the emotional training of students is important because it influences their financial behavior. Sjöberg and Engelberg [50] indicated that students have a strong tendency towards economic risktaking, achievement orientation, the search for emotions, and a relatively high level of EI. However, they detected a low trend in terms of the value of money, compared to other university students from different branches. Felton, Gibson, and Sanbonmatsu [51] found a relationship between students' optimism and the risk of their investments. Similarly, Saurilin et al. [52], after their research with university students from Portugal and Brazil, concluded that finance students showed less bias toward the status quo in their financial decisions than students without previous studies on finance. Oehler et al. [19] found that extraversion and neuroticism significantly influenced the financial behavior of university students. They pointed out that most extraverted students buy more financial assets when the assets are too expensive and that the more neurotic students have fewer risks in their financial portfolios.

Some studies have also detected the existence of a deficit in the EI of university students with respect to professionals that extends to a large part of the emotional competencies, highlighting among them self-motivation, the ability for emotional expression, and empathy [11,12]. Rzeszutek, Szyszka, and Czerwonka [53] demonstrated that susceptibility to financial behavior biases depends on the level of experience in the financial market and that some PTs such as impulsiveness and empathy are closely related to these biases.

3. Methods

3.1. Samples

The present study uses two different samples to solve the established research questions. On the one hand, there was a sample made up of a total of 240 students from the degrees of Economics, Business Administration and Management, and Finance and Accounting from a Spanish public university in the academic year 2019/2020, selected from those who had passed at least 80% of the total of the subjects. For this, a request for participation was sent to the population of students who met the characteristics indicated, obtaining a response of 45%. On the other hand, there was a sample made up of a total of 150 professionals selected randomly from among those who carry out their professional activities within the financial industry in the Spanish market in April 2020. Both samples completed EI and PT measurement questionnaires, with the specifications shown in the next section. These questionnaires were previously subjected to a methodological test to detect possible difficulties in their application. In this process, financial experts intervened and provided feedback that modified some questions and the addition of other elements to the final questionnaire. Of the total sample of students, forty-eight-point-zero-four percent were men, and fifty-one-point-nine-six percent were women. The mean age of the students was24.03 years, and fifty-three-point-nine-two percent of them had the intention of starting postgraduate studies at the end of their undergraduate studies. The socio-demographic characteristics of students in the sample appear in Table 1.

Table 1. Socio-demographic characteristics of the student sample.

	%
Women	51.96
Men	48.04
Average age	24.03 (years)
Postgraduate studies intention	53.92
Use of scholarship	67.65

In the sample of professionals, sixty percent were men, and forty percent were women, the average age of the participants being 44 years. Furthermore, one-hundred percent of the sample had a university degree, 10% a Ph.D. degree, and 30% a university Master's degree. Likewise, ten percent of the sample had experience in the financial industry of fewer than 10 years, 35% between 11 and 15 years, and 40% of the sample more than 16 years. The socio-demographic characteristics of the professionals in the sample appear in Table 2.

Table 2. Socio-demographic characteristics of the professional sample.

	%
Women	39.71
Men	60.29
Average age	43.55 (years)
University degree	100.00
University Master's degree	29.82
Ph.D. degree	9.75
Experience in the financial industry	
Less than 10 years	24.85
Between 11 and 15 years	35.40
More than 16 years	39.75

3.2. Instruments

Both the students and the professionals in the sample completed the EI measurement Trait Emotional Intelligence Questionnaire (TEIQue) [54] and the PT measurement Big Five Inventory (BFI) [55]. EI refers to a person's set of competencies to monitor and understand one's own emotions and those of others and use this affective information to guide one's thoughts and actions. In this study, the emotional competencies that were of particular significance due to their influence on the behavior of students and professionals in previous research were selected [11,56,57]. Furthermore, four dimensions of EI were considered (sociability, emotionality, self-control, and well-being) that grouped 15 emotional competencies [58–60]. The TEIQue version used in this study is the long version, which comprises 153 items, using a Likert-type measurement scale from 1 to 7 (1 = not at all agree and 7 = completely agree). A synthesis of the selected emotional dimensions and competencies appears in Table 3.

Table 3. Dimensions and emotional competencies in the emotional intelligence (EI) questionnaire.

Dimensions	Emotional Competencies	High Scorers See Themselves as
Sociability	Relationships	Able to maintain satisfactory personal relationships.
	Empathy	Able to take another person's perspective.
	Emotion perception	About your own and others' feelings.
	Emotion expression	Able to communicate their feelings to others.
Emotionality	Emotion management	Able to influence the feelings of others.
	Social awareness	Connected to superior social skills.
	Assertiveness	Frank and ready to defend their rights.
Self-control	Emotion regulation	Able to control their emotions.
	Adaptability	Flexible and ready to adapt to new conditions.
	Impulsiveness (low)	Thoughtful and less likely to give in to their impulses.
	Self-motivation	Unlikely to give up in the face of adversity.
	Stress management	Able to withstand pressure and regulate stress.
Well-being	Happiness	Satisfied with their lives.
	Optimism	Likely to "look on the bright side" of life.
	Self-esteem	Successful and self-confident.

For its part, PTs area set of qualities that describe the individual and that can be considered as key drivers of human behavior. In this regard, the BFI questionnaire used consists of 44 items grouped into five traits (extraversion, agreeableness, neuroticism, openness, and conscientiousness) selected from those that were of particular significance due to their influence on financial behavior [7,61]. This questionnaire uses a Likert-type scale of measurement from 1 to 5 (1 = not agree at all and 5 = completely agree). A synthesis of the BFI questionnaire used in the present study appears in Table 4.

Table 4. Personality traits (PTs) in the Big Five Inventory (BFI)questionnaire.

PT	Main Characteristics	Antagonistic Characteristics
Neuroticism	Anxiety, hostility, depression, shyness.	Calm, secure, relaxed, emotionally strong.
Extraversion	Search for emotions, assertiveness, positive emotions, cordiality.	Reserved, withdrawn, shy, lonely.
Openness	Emotional, imaginative, idealistic, depth.	Conventional, realistic, traditional.
Agreeableness	Helpful, cooperative, compassionate, conciliatory attitude.	Suspicious, individualistic, antagonistic.
Conscientiousness	Sense of duty, need for success, impulse control, aimed at accomplishing tasks.	Lazy, purposeless, weak will, careless in moral principles.

4. Results

4.1. Descriptive Analysis

Table 5 shows the levels of the emotional competencies of both the sample of students and of professionals. The differences between samples were analyzed using the Mann–Whitney test since the variables related to EI do not follow a normal distribution. The students presented lower levels than professionals in a large part of the emotional competencies, specifically in emotion regulation, relationships, self-esteem, self-motivation, stress management, empathy, optimism, and emotion perception (p-value < 0.05). However, in social awareness, students outperformed professionals (p-value < 0.05). Likewise, Table 5 offers the results of the descriptive analysis of the dimensions and the global score of EI. Students presented lower levels than professionals in three of the four EI dimensions (sociability, emotionality, self-control, and well-being) and globally. These results confirm that students have a deficit in EI compared to professionals.

Table 6 presents the results of the descriptive analysis of the PT variables corresponding to the sample of students and professionals. The differences between both samples were analyzed using the t-test since the variables related to personality follow a normal distribution. Students presented a lower average in agreeableness, openness, conscientiousness, and extraversion (p-value < 0.05), but in neuroticism, the average corresponding to students (2.66) was higher than that of professionals (2.39) (p-value < 0.05). These results also confirm that students presented significant differences with respect to professionals in all PTs, which may explain different behaviors in making financial decisions.

Table 5. EI of students and professionals in the sample.

	Median		S.D.		Min.		Max.		M-W
	S	P	S	P	S	P	S	P	
(A) Emotional competencies									
Adaptability	4.38	4.46	0.71	0.58	2.15	2.85	5.69	5.54	0.09
Assertiveness	4.14	4.43	0.72	0.77	2.71	3.14	6.14	6.29	0.14
Emotion expression	4.25	4.42	0.82	0.67	2.42	3.25	6.00	5.83	0.08
Emotion management	4.21	4.33	0.63	0.61	2.83	2.75	5.67	5.50	0.06
Emotion regulation	4.40	4.53	0.68	0.72	2.67	3.00	5.73	6.00	0.03 **
Impulsiveness (low)	5.00	5.00	0.83	1.08	2.60	2.80	6.60	7.00	0.65
Relationships	5.25	5.63	0.82	0.67	3.00	4.0	7.00	6.50	0.02 **
Self-esteem	4.76	5.24	0.76	0.64	2.29	3.47	6.41	6.53	0.00 ***
Self-motivation	4.75	5.00	0.71	0.59	2.75	3.75	6.63	6.25	0.02 **
Social awareness	4.67	4.33	0.63	0.55	2.83	3.00	6.33	5.67	0.03 **
Stress management	4.43	4.64	0.61	0.38	2.43	3.86	5.64	5.57	0.03 **
Empathy	4.33	4.56	0.52	0.57	3.11	3.44	5.33	5.67	0.04 **
Happiness	5.88	6.13	0.91	0.72	2.88	3.88	7.00	7.00	0.13
Optimism	5.00	5.33	0.84	0.55	3.00	4.22	7.00	6.33	0.04 **
Emotion management	4.30	4.40	0.60	0.63	2.70	2.80	5.50	6.20	0.03 **
(B) EI Dimensions									
Emotionality	4.26	4.32	0.46	0.39	5.40	5.40	3.32	3.64	0.13
Self-control	4.56	4.75	0.47	0.42	5.25	5.25	2.96	3.67	0.00 ***
Sociability	4.40	4.72	0.49	0.42	5.38	5.38	3.15	4.13	0.01 **
Well-being	5.06	5.47	0.72	0.52	6.41	6.41	2.97	3.91	0.00 ***
(C) EI Global									
EI global	4.58	4.79	0.41	0.33	5.47	5.47	3.56	4.12	0.00 ***

S: students; P: professionals; M-W: Mann–Whitney test; ***: Sig. at the 0.001 level; **: Sig. at the 0.05 level.

Table 6. PTs of students and professionals in the sample.

PT	Mean		S.D.		Min.		Max.		*t*-Test
	S	P	S	P	S	P	S	P	
Agreeableness	3.71	3.92	0.43	0.59	2.11	2.67	4.67	5.00	0.028 **
Openness	3.35	3.59	0.64	0.52	1.60	2.40	4.70	5.00	0.015 **
Conscientiousness	3.60	3.89	0.58	0.50	2.00	2.67	4.67	4.78	0.002 **
Extraversion	3.25	3.51	0.65	0.52	1.38	2.63	4.50	4.63	0.012 **
Neuroticism	2.66	2.39	0.75	0.62	1.38	1.00	4.38	3.75	0.033 **

S: students; P: professionals; **: Sig. at the 0.05 level.

4.2. Impact Analysis

The results obtained in the descriptive analysis indicated that there are significant differences between the EI and PTs of the university students and professionals in the financial industry. Besides, these differences represent a deficit for students compared to professionals in certain emotional skills and PTs. Therefore, the objective of this impact analysis is twofold. Firstly, we tried to identify if the student deficit was related to financial behavioral biases.Secondly, we determined the impact (positive or negative) on the different biases associated with the student deficit. The results of the impact analysis for EI appear in Table 7. Students presented a deficit in self-control compared to professionals. Taking into account the conclusions of previous literature [16], this should lead them to have endowment bias to a greater extent, that is to overvalue their assets and to make incorrect decisions in asset sales. Likewise, students presented a deficit in trait empathy, so they would have more optimism than professionals, reacting in an exaggerated manner to obtain superior performance [17]. Furthermore, the results show that students have deficits in emotion regulation, stress management, self-esteem, self-motivation, and relationships. According to the conclusions obtained by Dhiman and Raheja [32], this indicates that students are less risk tolerant than professionals, which may prevent them from making

aggressive investments to achieve higher returns in the medium to long term. Finally, and referring to global EI, we were also able to observe a deficit of students with respect to professionals. This aspect can lead them to have greater endowment bias, self-control, optimism bias, risk aversion, and regret aversion [29]. On the contrary, and due to this deficit in global EI, students were more risk averse than professionals, so they may tend not to analyze investment risk well.

Table 7. Students' EI gaps and impacts.

Skills, Dimensions, and EI Global	Associated Bias	Sense of Impact
Self-control	Endowment bias	−
Trait empathy	Optimism bias	−
Emotion regulation	Risk tolerance	+
Stress management	Risk tolerance	+
Self-esteem	Risk tolerance	+
Self-motivation	Risk tolerance	+
Relationships	Risk tolerance	+
Social awareness	Risk tolerance	+
EI global	Endowment bias	−
EI global	Self-control bias	−
EI global	Optimism bias	−
EI global	Loss-averse	−
EI global	Regret aversion	−
EI global	Risk-averse	+

Table 8 shows the results of the impact analysis of the deficit in PTs. Students had lower levels of openness and higher levels of neuroticism than professionals. Then, and as proposed by Hopfensitz and Wranik [41], they can be more risk averse than professionals, resulting in being more likely to make unfavorable investment decisions. Likewise, the results suggest that students have lower levels of openness, extraversion, and agreeableness, which implies that they are less risk tolerant than professionals and, therefore, that they have greater difficulty in building an aggressive portfolio that provides high returns [32].

Table 8. Students' PT gaps and impacts.

PT	Associated Bias	Sense of Impact
Neuroticism	Risk-averse	−
Openness	Risk-averse	−
Extraversion	Risk tolerance	+
Openness	Risk tolerance	+
Agreeableness	Risk tolerance	+

4.3. Discussion

The results of this study are comparable to other findings on students in the United States of America [11] about the deficit in EI presented by the students regarding professionals, in addition to the results of the study by [53], in which they found that experience in the financial market is related to different PTs presented by students and professionals.

The results obtained also indicate that the students in the sample had a deficit in emotion regulation, stress management, self-esteem, self-motivation, and relationships, so they must be less risk tolerant than the professionals. However, these results differ from those obtained by Lin et al. [46] and Felton, Gibson, and Sanbonmatsu [51] when concluding that students have a strong tendency towards economic risk tolerance. Other aspects related to the deficit in student EI and its effects on financial behavior biases have also been highlighted in this study. Such is the case of self-control, empathy, and global EI levels, which are associated with higher endowment bias, optimism bias, self-control bias, loss aversion, and regret aversion, respectively. However, there are no precedents for these results in the previous literature.

On the other hand, regarding the PTs, previous studies showed that impulsiveness, empathy, extraversion, and neuroticism are closely related to the biases of the financial behavior that students present [19,53]. Our results coincide with those previous studies only about the deficit in empathy, but they were not concerned with other PTs such as openness and extraversion, which have not been found in the previous literature, nor the higher levels of neuroticism that students present compared to professionals.

Differences in the levels of EI and PTs can condition the biases of the financial behavior of students with respect to professionals in the financial industry. Despite the significant differences observed, the results obtained show interesting findings for discussion. For example, there were no significant differences in adaptability, assertiveness, emotion expression, emotion management, impulsiveness (low), and happiness. Perhaps this is because a greater personal and work experience in the financial industry does not have the effect of developing certain emotional skills. This is also because university training programs succeed only in certain aspects of EI, pending significant advances in other emotional skills necessary for the better future financial behavior of students in the labor market.

5. Conclusions and Implications

The results of the present study confirmed that there are significant differences in EI and PT levels between students and professionals in the financial industry and that such differences are associated with biases in financial behavior. Students present a gap with respect to professionals about relationships, empathy, emotion perception, emotion regulation, self-motivation, stress management, optimism, and self-esteem, as well as in three of the EI dimensions and the global EI scores. Gaps in EI, therefore, indicate that students tend to have optimism bias, risk tolerance, self-control bias, loss aversion, and regret aversion to a greater extent. On the other hand, and as for PTs, students present a gap in agreeableness, conscientiousness, openness, and extraversion and higher scores in neuroticism, confirming that students are more likely to have risk tolerance bias.

Our study presents several contributions to the literature on financial behavior and financial education. First, and from a theoretical perspective, there are significant differences in the levels of EI and PT between university students and professionals in the financial industry that are associated with financial behavioral biases. Previous research has shown that EI and PT influence financial behavioral biases [6] and that university students present a gap in EI compared to professionals from other industries [11]. However, this is the first study to show that university students present a gap in EI and PTs compared to professionals in the financial industry and that this gap is related to some biases of the students' financial behavior. These conclusions open up new research perspectives on EI and PT in the framework of financial behavior and financial education. Likewise, the results obtained confirmed that university students present a gap compared to professionals only in certain emotional competencies and that these are related to optimism bias, risk tolerance, self-control bias, loss aversion, and regret aversion. The literature indicates the existence of other financial behavior biases [15], although there is no empirical evidence that relates them to either EI or PTs.

This study also presents important practical implications for the management of university education and financial companies. Universities should be aware of providing students with full EI and PT training to help them successfully tackle their professional future in the financial industry. Similarly, financial companies should be aware that young professionals have low-risk tolerance and more likely to have endowment bias, optimism bias, self-control bias, and loss aversion. In this way, they should design the management of their investment portfolios taking into account the EI and PT levels of their employees.

Finally, the results of this study suggest future research on financial behavior. First, given that theories of emotions and PTs have only explained some of the financial behavior biases, other studies could check if other theoretical frameworks could explain them. Second, future research should empirically check the financial behavior bias of students

about the deficits of EI and PTs discovered in the present study. Third, future research should address the effects of gender, age, and educational level on the EI and PTs of students and professionals related to the financial industry. Fourth, future research should study what training techniques could serve to correct the EI and PT differences between students and professionals. Last, although some previous work has pointed out that experiential learning techniques have corrected differences in EI, there are still very few that refer to improvements in PTs.

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Distance Learning Perceptions from Higher Education Students—The Case of Portugal

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Abstract: This research study examines the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university courses during the second semester of the academic year 2019–2020 during the COVID-19 pandemic. The methodology was quantitative, being the undergraduate and postgraduate students surveyed to find their perceptions about distance and online education in Portugal. The findings of the study highlighted the relationship between distance and online learning. The key concern of the respondents is related to the formal and contextual dimensions of the online class regime. The values examined, taken as a whole, allow us to conclude that with this teaching regime, in terms of awareness, there is acceptance and benefit. The sense of ambiguity in which this transformation took place, as well as the climate surrounding this phase, are worth noting. The teaching and evaluation methodologies used have been embraced and show a very wide range of choices on the part of the teaching teams and the students' various interests, just as in the teaching regime of the classroom. The fact that students feel the need for face-to-face classes, however, is of great importance for practical and laboratory classes. This reality, which is a challenge to face in the future, is hard to overcome.

Keywords: distance learning; higher education; online learning; digital pedagogies; students

1. Introduction

1.1. Conceptualization of Distance and Online Learning

In the literature, distance and online learning is a dynamic concept with several different interpretations. Some characterize digital learning with unexpected outcomes as an unplanned and implied process [1–3] utilizing many types of technical devices, such as smartphones, tablets, computers, and others. In the context of this definition, this study aims to analyze the impacts of distance learning on students during the COVID-19 pandemic in the second semester of the academic year 2019–2020, but also the process itself. The goal during that period was to limit meetings involving physical contact in an effort to reduce the spread of the COVID-19 virus. These conditions had implications for the effectiveness of the learning process in higher education [4,5].

In literature, based on diverse studies realized during 2020, the main platforms used to teach was Zoom, Microsoft Teams, and Google Classroom, and the classes become to be too intense for the students, with too many assignments, and a big concern related to laboratory classes. However, activities as Chatting, Forum, Choice, and Assignment, could be more structured, and used as a support for the

distance learning process, but were not implemented as it should be to facilitate the learning process and to increase the learning outcomes [6,7].

1.2. Distance Learning in a Pandemic Context

The possibilities of increasingly interactive resources in the globalized world have changed the concept of communication and the sharing of education linked to innovative technologies. Since the technology linked to communication contributes to access to education and this has been expanded through digital communication networks. The innumerous paths are taken by innovation linked to technology point to different realities and orientations in the process, new methods in the educational context [4]. Over the years educational methodologies and methods have shifted. Today, in addition to expanding its output and thereby supporting people with disabilities, the instructor has engagement technology, such as interactive boards, online conferences, and other resources to strengthen the teaching and learning process [2,3]. The development of technology has been inspired by many of the "new" ways of learning and teaching. Digital instruments have contributed to the increasing development and distribution of information as strategies that provide tools. The Internet allowed new forms of computer-based learning, with virtual classrooms [8], a scenario guided by technology convergence that brought about revolutionary elements of learning, as it was characterized by the availability of texts, audio, and video on the same communication channel [1], allowing geographical, temporal and above all, communication barriers to be transposed. In a pandemic global situation, people are digitally linked in a knowledge-based society [9], living an educational scenario where digital education is nuclear to all levels of formal education.

Some concerns about distance learning in the pandemic situation includes the analysis of the following variables: [1–3] impacts on the academic journey; study schedule; place of study; moments of isolation; level of preparation; level of adaptation; satisfaction with the online classes format; and study time involved in the online learning process.

1.3. Contexts, Pedagogies, and Tools for Distance Learning

To involve students in the learning process, educators use technology, and several studies have shown signs of increased interest in learning when interactive technologies are integrated into the learning environment. It is possible to describe the pedagogical strategies to use innovations in the educational context as [8,9]: Open strategy, which provides access to information and knowledge creation for all with an emphasis on versatile content; Constructive strategy, which combines openness with its progressive construction to new spaces of knowledge; and Interactive strategy, which presupposes the development of the interactive processes that occur in the virtual environment.

Any pedagogy involving distance learning technologies must explore the different potentialities of these technologies: context, mobility, informality, appropriation of the tool by the student. They offer greater control and autonomy over learning itself [4–6]. Furthermore, it enables learning in context, that is, at the place, time, and under the conditions that the student deems most appropriate. It also allows continuity and connectivity between contexts [7]. For example, while the student moves in a certain area or during an event, he may be in constant contact and connected with his peers and with didactic content. Finally, it contributes to spontaneity and opportunism in the learning process, since the learner can take advantage of times, spaces, and any opportunities to learn spontaneously, according to his interests and needs [5].

In distance learning contexts, students are required a great degree of autonomy, passing on to them a great responsibility for their learning [6,7]. Learning situations are influenced by several factors [6,7]: (a) the professor is a facilitator of learning, assuming several roles simultaneously: moderator, participant, and observer; (b) the student that interacts with the professor and also with the other elements of the learning group; (c) space and time for carrying out learning in a global perspective, depending on the learning needs of each one; (d) the context of the learning that must be directed towards the student's needs.

The main contexts of learning present in the literature are very diverse, as presented in the following Table 1:

Table 1. Distance and online learning technologies and pedagogies.

Distance and Online Learning	Authors
Online Learning Tools	
• E-mail • Smartphone/Videochat • International Communication Platform (e.g., Zoom, Google Hangouts . . .) • E-Learning Platform or a similar tool • Communication facilitators • Conference Calls • Chat – chatroom • Conferences (video and audio) • Electronic Mail • Discussion forums	[10] Barber, W.; King S.; Buchanan, S. (2015) [11] Sousa, M.J.; Rocha, Á. (2019) [12] Liyanagunawardena, T.; Lundgvist, K.; Williams, S. A. (2015) [13] Liwen, C.; Tung-Liang, C.; Nian-Shing, C. (2015) [14] Masterman, E. (2016) [15] Salmon, G.; Gregory, J.; Lokuge, D. K.; Ross, B. (2015) [16] Sohrabi and H. Iraj, (2016) [17] Stewart, B. (2015) [18] Thibaut, P.; Curwood, J. S.; Carvalho, L.; Simpson, S. (2015) [19] Trotskovsky and Sabag, N. (2015)
Equipment	
• Desktop computer • Laptop • Tablet • Smartphone	[15] Salmon, G.; Gregory, J.; Lokuge, D.; Ross, B. (2015) [17] Stewart, B. (2015) [20] Xu, H. (2016) [21] McNaughton, S. M.; Westberry, N. C.; Billiot, J. M.; Gaeta, H. (2014) [22] Martin-Garcia, M. Serrano and Gomez, M (2014) [23] Sungkur, R. K.; Panchoo, A.; Bhoyroo, N. K. (2016) [24] Tena, R. R.; Almenara, J. C.; Osuna, J. B. (2016)
Pedagogical Techniques	
• Clarification sessions • Availability of pedagogical materials in video format • Availability of pedagogical materials in text format • Group work • Individual work • Small groups discussion • Availability of pedagogical materials in audio format • Large groups discussion • Pedagogical games • Simulations/role play • Case studie	[8] Sousa, M.J; Cruz, R.; Martins. J.M. (2017) [10] Barber, W.; King S.; Buchanan, S. (2015) [25] Friend, J.; Militello, M. (2014) [26] Guzman, G.; Hernandez, M.; Pirez, R. (2014) [27] Kosonen, K.; Ilomaki, L.; Lakkala, M., (2015) [28] Lau, K. H. (2014) [29] Mantri, A. (2014) [30] Moorefielf-Lang H.; Hall, T. (2015) [23] Sungkur, R. K.; Panchoo, A.; Bhoyroo, N. K. (2016) [31] Munoz Gonzales, J. M.; Rubio, S. G.; Pichardo, M. C. (2015) [32] Nielsen W.: Hoban, G. (2015) [33] Rai, S. S.; Gaikwad, A. T.; Kulkarni, R. V. A (2014) [34] Rudow, J.; Sounny-Slitine, M. A. (2015) [35] Stansbury, J. A.; Earnest., D. R. (2017) [36] Unger; R.; Kulhavy, D. L.; Busch-Petersen, K.; Hung, I.-K. (2016) [37] Wood D.; Bilsborow, C. (2014)

Table 2 presents the possible evaluation methods of distance learning, identifying in the analysis of the literature:

Table 2. Evaluation Process on Distance Learning in Higher Education.

Evaluation method	Authors
• Face-to-face • Online through individual work • Online through group work • Online tests	[23] Sungkur, R. K.; Panchoo, A.; Bhoyroo, N. K. (2016) [25] Friend, J.; Militello, M. (2014) [27] Kosonen, K.; Ilomaki, L.; Lakkala, M., (2015) [32] Nielsen W.: Hoban, G. (2015) [35] Stansbury, J. A.; Earnest., D. R. (2017) [37] Wood D.; Bilsborow, C. (2014)

All the tools present in Tables 1 and 2 can be used in learning contexts by contributing to facilitate student learning process, and toward the improvement of academic results. However, in the following

analysis, it is possible to see that the students didn't use the potentialities of these tools as the pandemic situation created a special context that affected their application.

1.4. Obstacles Involved in the Online Learning Process

Distance learning also has several obstacles, of which the following refer [38]

1. Less student/teacher interaction, as the interaction of the student/teacher, becomes reduced since the communication is made via the Internet, originating as such a physical and/or temporal distance.
2. Less motivation and rhythm drive a lack of concentration and a lack of students' interaction.
3. It requires more time in the preparation of content and training, and excess of activities and works proposed to the students.
4. Difficulty in time management and difficulty in balancing family and academic life. L
5. Lack of technology skills by professors and students.
6. Lack of equipment by Professors and students.
7. Internet access speed and costs, as this system requires the use of the Internet as a crucial tool for communication, resulting in its use costs.
8. Bandwidth, which does not always efficiently support the transmission of content.

1.5. Advantages Involved in the Online Learning Process

It is also important to analyze the advantages of this type of learning, which facilitate the teaching and learning process [38]: Learn anytime and anywhere, since the materials are available twenty-four hours, and can be accessed from any location, allowing any trainee to join a given training, without the usual inconvenience; time-saving, as there is no need to travel to training, which causes so many inconveniences and becomes a barrier to training; the student learns at their own pace, and the student becomes autonomous, being responsible for their learning. He can choose the content and set their own pace, and the course contents can be reused in other courses partially or totally, with up-to-date information.

1.6. Hypotheses

This study aims to analyze the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university courses during the second semester of the academic year 2019-2020 during the COVID-19 pandemic. The relationship between the pandemic impact and attitudes is explored regarding compulsory digital and distance learning and the intention to maintain the online format for the next year. Three main hypotheses were tested:

Hypothesis H1: *There a negative correlation between the pandemic impact on the academic journey and the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university;*

Hypothesis H2: *There a positive correlation between the satisfaction with online classes format and the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university;*

Hypothesis H3: *Is there a significant difference between the perception of the pandemic impact on the academic journey and the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university regarding the group of students that want to maintain the online format for the next school year and the group of students that don't want to maintain the online format for the next school year?*

2. Methods

2.1. Data Collection Procedure

An online survey was developed through the Google Forms platform and sent to higher education student associations with the available online contacts. The survey was active between August and October of 2020. The instrument's application lasted 10 min on average.

The ones who answered were informed of the anonymous and confidential nature of the collected data, noting that their participation in the survey was voluntary and there was no monetary or another kind of reward.

2.2. Data Analysis Procedure

The data was analyzed by SPSS software (26.0 version). The variables under study were characterized using descriptive and frequency statistics. Variables relationship were explored by Spearman Rho Correlation, and the *t*-test was used to explore the differences between the students that want and do not want to maintain the online format in the next school. year.

2.2.1. Instrument

The survey was presented in two sections, the first one relating to the experience of distance learning during the period of the COVID-19 lockdown, focusing on distance learning's satisfaction as well as the obstacles and advantages, and the second one was composed of a sociodemographic and academic characterization group.

2.2.2. Participants

The global sample included 173 university students. In terms of sociodemographic characteristics, the participants were mostly female (n = 142; 82.1%), single (n = 157; 90.8%) with an average age of 24 years old (SD = 7.42). Majority of the ones inquired are from public universities (n = 151; 87.3%). The most common cycle of studies is the first cycle (n = 116; 67.1%), next is the second cycle (n = 52; 30.1%) and lastly is the third cycle (n = 5; 2.9%). From the participating scientific areas of the course, the ones that stood out were Law, Social Sciences and Services (n = 43; 24.9%); Health (n = 34; 19.7%) and Economics, Management and Accounting (n = 21; 12.1%). The school year the participants are in goes from the first one (n = 20; 11.6%); second one (n = 51; 29.5%); third one (n = 63; 25.9%); followed by the fourth until sixth one (n = 39; 22.5%). Only 26.6% (n = 46) are working students.

3. Results

3.1. Concern About the Pandemic and its Impacts on the Educational Path

Table 3 illustrates the students' perceptions of the concern and impact that the Covid-19 pandemic will have on their academic journey. The students inquired are very concerned (n = 76; 43.9%) and extremely concerned (n = 48; 27.7%) about the pandemic.

Table 3. Pandemic's impact on academic journeys.

Concern about the Pandemic	Frequency	%	Academic Journey	Frequency	%
Not concerned	2	1.2	No impact	6	3.5
A little concerned	3	1.7	A little impact	9	5.2
Concerned	44	25.4	Impact	29	16.8
Very concerned	76.8	43.9	A lot of impacts	66	38.2
Extremely concerned	48	27.7	A high impact	63	36.4
Total	173	100.0	Total	173	100.0

The majority of the 74.6% (n = 129) of the participants report that the COVID-19 pandemic will have a quite high impact on their academic journey.

3.2. Schedule, Place, and Specific Isolation Moments to Study

Regarding the study schedule, as can be seen in Table 4, 70.5% (n = 122) of the participants reported not having a specific Schedule. Regarding the specific place of study, there seems to be greater stability since most of the answers were "always" (n = 71; 41.0%). The specific moments of isolation to study seem to have been achieved quite often or always for 46.8% (n = 81) of the participants (Table 4).

Table 4. Schedule, place, and specific *isolation* moments to study.

Variables	Study Schedule		Place of Study		Moments of Isolation	
Answers	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Never	27	15.6	13	7.5	17	9.8
A few times	31	17.9	16	9.2	27	15.6
Sometimes	64	37.0	39	22.5	48	27.7
Quite often	24	13.9	34	19.7	50	28.9
Always	27	15.6	71	41.0	31	17.9
Total	173	100.0	173	100.0	173	100.0

3.3. Higher Education Institution (HEI) and Its Previous and Current Level of Preparation

Table 5 shows the perception of the higher education institution's level of preparation and adaptation concerning the COVID-19 pandemic. Regarding the institution's level of preparation, 120 (64.4%) of the inquired reported between nothing and partially prepared. Regarding the level of adaptation, at this moment, most of the answers (n = 90; 52%) are found between very and fully adapted.

Table 5. Level of preparation and adaptation of the institution concerning the COVID-19 pandemic.

Variables	Level of Preparation		Level of Adaptation	
Answers	**Frequency**	**%**	**Frequency**	**%**
Nothing prepared/adapted	32	18.5	12	6.9
Poorly prepared/adapted	43	24.9	26	15.0
Partly prepared/adapted	45	26.0	45	26.0
Very prepared/adapted	45	26.0	67	38.7
Fully prepared/adapted	8	4.6	23	13.3
Total	173	100.0	173	100.0

3.4. The Experience on Distance Learning

Regarding the course of their studies, the majority of participants were having online classes instead of face-to-face teaching (n = 170; 98.3%), considering that for 94.8%, it was their first experience of online classes.

Students are satisfied with the **online class format** (Table 6).

Table 6. Satisfaction with the online classes format.

Satisfaction with the Online Classes Format	Frequency	%	Mode
Not satisfied at all	24	13.9	
Not very satisfied	37	21.4	
Satisfied	60	34.7	3 = Satisfied
Very satisfied	35	20.2	
Totally satisfied	17	9.8	
Total	173	100.0	

When questioned if they dedicated their time to study in the online format more than they would in a face-to-face format, the answers are well-balanced with 53.2% (n = 92) saying no while 46.8% of participants (n = 81) saying yes (Table 7).

Table 7. Estimation of more study time involved in the online learning process compared with face-a-face learning process.

Answers	Frequency	%
Yes	81	46.8
No	92	53.2
Total	173	100.0

Regarding the equipment used, most participants use a laptop with more regularity (n = 167; 62.1%) (Table 8).

Table 8. Equipment used more frequently by the students.

Equipment	Frequency	%
Desktop computer	10	3.7
Laptop	167	62.1
Tablet	26	9.7
Smartphone	66	24.5
Total	269	100.0

In terms of the tools used by Professors, the most used was the International Communication Platform (e.g., Zoom, Google Hangouts . . .) (n = 168; 41.8%) and e-mail (n = 146; 36.3%) (Table 9).

Table 9. Online Learning Tools.

Online Learning Tools	Frequency	%
E-mail	146	36.3
Smartphone/Videochat	31	7.7
International Communication Platform (e.g., Zoom, Google Hangouts . . .)	168	41.8
E-Learning Platform or a similar tool	57	14.2
Total	402	100.0

The participants point out the use of the conference resource (video and audio) as a means of communication facilitating the learning process (Table 10).

Table 10. Communication facilitators.

Communication Facilitators	Frequency	%
Conference Calls	12	6.9
Chat – chatroom	6	3.5
Conferences (video and audio)	129	74.6
Electronic Mail	21	12.1
Discussion forums	5	2.9
Total	173	100.0

The replies show that a diversity of pedagogical techniques was used, as the clarification sessions' expression, availability of pedagogical materials in video and text format as well as group work (Table 11).

Table 11. Pedagogical techniques used.

Pedagogical Techniques	Frequency	%
Clarification sessions	136	18.0
Availability of pedagogical materials in video format	133	17.6
Availability of pedagogical materials in text format	116	15.3
Group work	114	15.1
Individual work	72	9.5
Small groups discussion	61	8.1
Availability of pedagogical materials in audio format	45	5.9
Large groups discussion	30	4.0
Pedagogical games	29	3.8
Simulations / role-play	19	2.5
Case studies	2	0.30
Total	757	100

When questioned about the balance of this online teaching experience, the viewpoints differ, positioning themselves between the scale's midpoint and a slight positive connotation. This result of ambiguous position is reinforced when questioned if they consider that face-to-face teaching's replacement by distance learning methodologies had a positive result with 51.4% (n = 89) saying yes and 48.6% (n = 84) saying no, as well as when questioned about this format's maintenance in the following school year, 56.1% (n = 97) saying yes and 43.9% (n = 76) saying no.

The issue of the maintenance of the format was complemented with the justification request which was the content analysis' subject. The reasons pointed out for not wanting to maintain the format are associated with the reconciling difficulty of this format with practical classes, technological constraint, especially the internet one, and the need for social proximity with colleagues and Professors. The reasons pointed out to support this format's continuity are associated with the security made possible while in a pandemic and time and location's flexibility (Tables 12 and 13).

Table 12. Balance of the online teaching experience.

Balance	Frequency	%
Very negative, was far below expectations	14	8.1
Negative	26	15.0
Reasonable	55	31.8
Positive	53	30.6
Very positive, has far exceeded expectations	25	14.5
Total	173	100.0

Table 13. Balance and maintenance of the online format.

Variables	A Positive Result of Replacing Face-To-Face Education with Distance Learning Methodologies		Maintenance of The Online Format in The Next School Year	
Answers	Frequency	%	Frequency	%
No	84	48.6	76	43.9
Yes	89	51.4	97	56.1
Total	173	100.0	173	100.0

The most pointed out were online tests (n = 145; 42.9%), followed by individual (n = 97; 28.7%) and group (n = 84; 24.9%) online works, with students being reasonably satisfied (n = 66; 38.2%) and very satisfied (n = 48; 27.7%) about the evaluation's format (Tables 14 and 15).

Table 14. Evaluation method.

Evaluation Method	Frequency	%
Face-to-face	8	2.4
Online through individual work	97	28.7
Online through group work	84	24.9
Online tests	145	42.9
Others	4	1.2
Total	338	100

Table 15. Evaluation's format satisfaction.

Satisfaction	Frequency	%
Not satisfied at all	13	7.5
Not very satisfied	29	16.8
Reasonably satisfied	66	38.2
Very satisfied	48	27.7
Extremely satisfied	17	9.8
Total	173	100.0

3.5. Opinions on Online Teaching

The participants positioned their agreement level with a set of statements on a five-point scale where 1 represents "I totally disagree" and 5 represents "I totally agree". The means' analysis allows us to verify that students report numbers above the scale's midpoint on their preference for the face-to-face format (mean = 3.82) and that this format requires significant changes for the students (mean = 3.62) (Table 16).

Table 16. Opinions on online teaching.

Opinions	Mean	Standard Deviation
I prefer the face-to-face classes format	3.82	1.385
Online teaching requires significant changes for the student	3.62	1.153
Online teaching allows me to save time	3.42	1.435
Online teaching is more functional in terms of schedules	3.4	1.363
I felt comfortable with online classes	3.38	1.263
The execution of asynchronous tasks is useful to assure the learning of the classes' contents	3.38	1.168
My Higher Education Institution has always sought the best for all students	3.23	1.258
Asynchronous tasks between synchronous classes make it easier to concentrate in class	3.02	1.215
I believe I learn the same in either online or face-to-face classes	2.44	1.304
I can learn better with online classes	2.39	1.433

3.6. Obstacles Involved in the Online Learning Process

Participants were asked to highlight the obstacles involved in the online learning process. The obstacles listed were highlighted 851 times by the participants and only 16 of them considered not to have obstacles. It is possible to highlight the excess of activities and works proposed (n = 112; 19.9%) and lack of concentration (n = 109; 12.6%) (Table 17).

3.7. Advantages Involved in the Online Learning Process

Participants were asked to indicate the advantages involved in the online learning process. The advantages listed were noted 417 times by the participants and only 19 participants considered that there were no advantages. The flexibility of location (n = 133; 30.5%) and time (n = 91; 20.9%) stands out (Table 18).

Table 17. Obstacles involved in the online learning process.

Obstacles	Frequency	%
Excess of activities and works proposed	112	12.9
Lack of concentration	109	12.6
Lack of students' interaction	87	10.0
Difficulty in time management	72	8.3
Lack of technology skills by Professors	70	8.1
Difficulty in balancing family and academic life	68	7.8
Lack of motivation and effort by students and families	67	7.7
Lack of support from Professors	56	6.5
Lack of support from the Higher Education Institution	50	5.8
Lack of motivation and effort by Professors	46	5.3
Lack of equipment by students	31	3.6
Lack of support from the Government and the Ministry	28	3.2
Lack of equipment by Professors	18	2.1
Additional costs with equipment	17	2.0
Lack of technology skills by students	16	1.8
Other obstacles	4	.50
No obstacles	16	1.8
Total	867	100.0%

Table 18. Advantages involved in the online learning process.

Advantages	Frequency	%
Time flexibility	91	20.9%
Location flexibility	133	30.5%
It was a contribution to more easily manage confinement	86	19.7%
Best academic results	54	12.4%
Ease of managing family and professional tasks with the course	49	11.2%
Other advantages	4	0.9%
No advantages	19	4.4%
Total	436	100.0%

3.8. Relationship Pandemic and Distance Learning Experience

The mode analysis reveals that students are reasonably satisfied (point 3 in answer scale) with the online format and the evaluation's format and consider HEI partly prepared (point 3 in answer scale) to deal with COVID-19. Students also reveal a lot of concern with the impact of the pandemic situation on the academic journey (point 4 in answer scale) and consider HEI to be well adapted (point 4 in answer scale).

Through Spearman's rho analysis (Table 19), it was found a statistically significant and inverse correlation between pandemic impact on the academic journey and all the other variables, thus the more students perceive the impact of the pandemic on academic life, the less they are satisfied with the online experience and evaluation; Balance of the online teaching experience is less positive, as well as the level of adaptation. On the other hand, there are positive and significant correlations between satisfaction with the online classes format and evaluation's format, level of preparation, and adaptation of HEI.

Table 19. Mode and Correlations.

Variables	Mode	1	2	3	4	5
1. Satisfaction with the online classes format	3					
2. Pandemic impact on the academic journey	4	−0.495 **				
3. Level of preparation of the HEI concerning the COVID-19	3	0.360 **	−0.139			
4. Level of adaptation of the HEI concerning the COVID-19	4	0.280 **	−0.183 **	0.412**		
5. Evaluation's format satisfaction	3	0.596 **	−0.349 **	0.179 **	0.193 **	
6. Balance of the online teaching experience	3	0.764 **	−0.487 **	0.279 **	0.303 **	0.665 **

Note. ** $p = 0.000$.

Due to the pandemic situation and the probable necessity of maintenance of the online format in the next school year, it has explored the differences between groups based if they want or do not want to maintain the online format in the next school year (Table 20).

Table 20. Differences between a student that want or do not want to maintain the online format on the next school year.

Variables	Maintenance of the Online Format in the Next School Year	N	Mean	Standard Deviation	T-Test
Pandemic impact on the academic journey	No	76	4.36	0.743	$t_{(166.399)} = -4.580$, $p = 0.000$
	Yes	97	3.70	1.129	
Level of preparation of the HEI concerning the COVID-19	No	76	2.61	1.234	$t_{(152.819)} = -1.268$, $p = 0.207$
	Yes	97	2.84	1.115	
Level of adaptation of the HEI concerning the COVID-19	No	76	3.22	1.103	$t_{(171)} = -1.485$, $p = 0.139$
	Yes	97	3.47	1.100	
Satisfaction with the online classes format	No	76	2.24	0.978	$t_{(171)} = -7.751$, $p = 0.000$
	Yes	97	3.43	1.030	
Evaluation's format satisfaction	No	76	2.62	0.993	$t_{(171)} = -6.604$, $p = 0.000$
	Yes	97	3.58	0.911	
Balance of the online teaching experience	No	76	2.59	1.073	$t_{(140.823)} = -8.187$, $p = 0.000$
	Yes	97	3.82	0.854	

Students who intend to maintain the online format rate the pandemic as having the least impact on the academic journey (mean = 3.70), are more satisfied with the online format (mean = 3.43) and with the evaluation's format (mean = 3.58) and make a more positive balance of the previous experience (mean = 3.82). No difference was found in the assessment of the preparation and adaptation of the institutions.

4. Conclusions

The pandemic has brought exceptional circumstances to teaching that require questioning the teaching methodologies used. To this end, a questionnaire with two sections was prepared, the first related to the distance learning experience during the hospitalization period by COVID-19 and the second composed of a set of sociodemographic and socio-academic characteristics.

This context was new and different—for 94.8% of the sample, it was the first experience with online classes. In general, students showed an ambivalent position concerning distance learning. Online is important to them given their concern about the pandemic and as a protector in this context. The results would be different in a non-pandemic context.

In terms of logistics and form issues, we can assume there is a lack of specific hours 70.5% (n = 122) of the participants reported not having a specific time and only (n = 71; 41.0%) always uses the same place of study/classes, which translates into a huge difference compared to the face-to-face education system.

Regarding the preparation of the institutions, the majority considers that they were not prepared at all (64.4%) for this change in functioning, but 52% recognize that they have adapted a lot or totally.

Among the various tools used, the Teaching Institutions used more the international communication Platform (e.g., Zoom, Google Hangouts ...) (41.8%) and the majority of participants used the laptop as equipment with more regular use (n = 167; 62.1%).

The analysis of the averages allows verifying that the students report values above the midpoint of the scale at the level of preference for the classroom format (average = 3.82) and that this format requires significant changes for the student (average = 3.62).

The barriers associated with the online regime listed were reported 851 times by the participants and only sixteen participants considered that there were no barriers. The excess of activities and

work proposed (n = 112; 19.9%) and the lack of concentration (n = 109; 12.6%) were highlighted by the students.

The two main advantages associated with the online regime were the location flexibility (n = 133; 30.5%) and time (n = 91; 20.9%).

About Pedagogical Issues we have some respondents highlight the use of conferences (video and audio) as a means of communication that facilitates the learning process (n = 126; 74.6%).

The responses demonstrate that a variety of teaching techniques were used. The expression of the Sessions to clarify issues, the provision of teaching materials in video and text format stands out, as well as group work.

The issue of maintaining the format was complemented by the justification request that was the subject of content analysis. The reasons given for not wanting to keep the format are associated with the difficulty of reconciling this format with practical classes, technological constraints, namely, the Internet, and the need for social proximity with colleagues and teachers.

In terms of assessment, online tests were the most referenced (n = 145; 42.9%), followed by individual online work (n = 97; 28.7%) and in group work (n = 84; 24.9%), with the students being reasonably satisfied (n = 66; 38.2%) and very satisfied (n = 48; students reasonably satisfied (n = 66; 38.2%) and very satisfied (n = 48; 27.7%) with the format of the assessments.

In short, from the analysis of the responses obtained, it seems to us that the greatest concern of the respondents is related to formal and contextual aspects concerning the regime of online classes. The analyzed values, taken as a whole, allow us to infer that there are acceptance and profit, in terms of knowledge, with this teaching regime. It is worth mentioning the context of uncertainty in which this transition took place, as well as the environment that surrounded this process.

The evaluation methodologies used were accepted and reveal a very wide range of choices on the part of the teaching teams and different preferences of the students, as in the classroom's teaching regime.

Results confirm the two first hypotheses to be essentially draws. Therefore, it there a negative correlation between the pandemic impact on the academic journey and the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university. Therefore, the more the students perceive the pandemic as having an impact on their academic journey, the less they are satisfied with online class formats and evaluation formats, also the perception was less that HEI is prepared and adapted to the pandemic situation and was evaluated as the worst of the online teaching experience. As expected, if there was a positive correlation between the satisfaction with the online classes format and the attitudes of Portuguese higher education students regarding compulsory digital and distance learning university, this means that the more the students were satisfied with online classes, the more positive were their attitudes regarding pandemic impact, level of HEI preparation and adaptation, satisfaction with evaluation format and general balance of the experience. This result highlights the significance of education as a helpful mechanism to deal with emergency situations [39].

The third hypotheses were partially supported. No differences were found in the level of preparation and adaptation of HEI. However, results show that the students that want to maintain the online format in the next school year are those that are more satisfied with evaluation format and online class formats and that do a more positive general balance of the online teaching experience. This result points out that it is more valuable for students that pedagogical issues than the institutional aspects. Therefore, the intervention focus should be in this field, institutions should invest in teacher training and eLearning platforms.

The sample size should be reported as a limitation of the study; however, the focus was on having a heterogeneous sample and not prolonging data collection for too long in order to have some contributions to the new school year. Assuming that the larger the population size, the smaller the percentage of the population needed to get a representative sample [40] and considering the minimum value for the data analysis procedures it was aiming to perform [41]. During the pandemic, there was an intensification of research, which may have contributed to the failure to fill. Data collection took place

at the beginning of the school year, which may have affected questionnaire adherence. In the future, it will be interesting to replicate this study throughout the school year, thus being able to function as a tool for monitoring distance learning. Therefore, by analyzing the online teaching experience, we can infer that the students who found it useful assigned an average of 3.82, a very significant value that represents availability to repeat the experience.

In terms of future research, it is important to understand the consequences of this type of teaching on the success of students, both in terms of the repetition of Curricular Units and in terms of the obtained classifications.

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Article

The Unbearable Lightness of Academic Fraud: Portuguese Higher Education Students' Perceptions

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Abstract: The perception that academic fraud is widespread in higher education affects the credibility of higher education schools, giving rise to doubts concerning the quality of learning and the students' preparation for their professional life. Academic misconduct is presently a common research area. However, higher education schools still seem unable to contain academic fraud, given its prevalence and scope. Therefore, understanding students' perceptions and attitudes remains critical for schools to define effective policies in promoting and defending academic integrity. Towards that aim, the results from a set of focus groups of students from a higher education school are presented. Students do not link academic fraud with unethical professional behaviour, propose more sanctions for those who commit academic fraud, and consider that certain evaluation methods favour unethical behaviour.

Keywords: academic fraud; academic integrity; higher education; perceptions; students

1. Introduction

Academic fraud seems to have spread, or its prevalence has recently received greater awareness, so its prevention is a clear concern of higher education institutions. Indeed, we know that academic fraud affects the credibility of students' learning assessments, and as a result, the institutional image of educational establishment is also affected, and neither is easy to rehabilitate. This is borne out by the news that recently came to public attention in Portugal in 2018 and 2019, motivated by a study carried out by a team from the University of Coimbra, of the disclosure of the lack of registration of cases of academic fraud by universities, or even of identified cases of academic fraud at the Masters and PhD levels, involving people in public offices.

Research into the phenomenon has made it possible to gain a better understanding of the topic, but higher education establishments' decisions in this matter frequently ignore scientific knowledge, although they are aware of the fraud problem and are looking to control it. This prompted us to investigate Portuguese students' perceptions of academic fraud using a qualitative approach to explore it in depth and to identify if any issues need further study. Quantitative approaches have been most frequent in studying academic fraud, which leaves no scope to explore aspects less targeted for investigation. The aim of this investigation is to understand what Portuguese higher education students understand by academic fraud. The analysis of these students' perceptions is expected to produce useful knowledge for higher education institutions to improve the teaching–learning system regarding the prevention of academic fraud. To contribute theoretically to the systematic knowledge on this subject, this paper focuses on less-explored dimensions in the literature, such as the relationship between the social representations students have of academic fraud and professional ethics and the multidimensional character of the concept of academic fraud. New insights in academic fraud research

are also expected by adopting a qualitative methodology, namely by using focus groups, which was used little in the studies we reviewed.

2. Literature Review

Academic fraud can be conceptualised as implying deliberate intent to deceive. For Epstein [1], it is an intentional effort to deceive, and he considers that a mistake made honestly or a mere difference of opinion, interpretation, or judgment does not constitute academic fraud. Other authors, such as Barnhardt [2], agree that when academic dishonesty is mentioned, an intention is implied. Referring to plagiarism, others point out that several studies show that cases in which plagiarism is practised with the intention of deception constitute a minority of cases [3,4]. The lack of knowledge about academic work and possible different interpretations of academic practices seem to be the main motive for academic fraud. This justifies the claim that academic fraud for some authors should not be regarded as a moral or ethical issue [5–8], although other works still focus on the dishonesty of pupils [9–12].

Regarding the need to address academic integrity, Gallant [13] stresses that he has long advocated a pedagogical approach to problems of academic misconduct, rather than a moral approach, but that in 2006/2007, he did not imagine the emergence of an industry associated with academic fraud, reintroducing the question of intentionality, such as that of the ghostwriters White [14] wrote about.

Although academic fraud is not a recent phenomenon, it can be said that it is a feature of the evolution of education, particularly at the higher education level, and the literature on fraud in higher education has also been growing [1]. The Bowers study, published in 1964, is recognised as the first to focus on fraud in higher education [3,9], and the study by McCabe and Trevino in 1997 is also a milestone [9]. Currently, however, a search from 1958 to 2020 with the keywords "Academic Fraud" in the subject yields 728 publications, which include academic journals, reports, news, and other journals (search conducted on www.b-on.pt, a Portuguese Online Knowledge Library, in February 2020). Looking at these results by decade reveals that 79% of publications are from 2011 to 2020, showing that the academy's research and publishing on the subject has mainly been in the last decade, perhaps because the problem has become more acute over the years despite a lack of awareness of how to contain it, or as a result of the massification of higher education and the growing heterogeneity of students who access it [4]. However, deeper research shows that the way in which academic fraud is viewed has also evolved over time. In fact, the four publications from 1958 to 1980—the last publication in this interval dates from 1975—focus on issues that, in the light of 2020, seem very far away, one of them portraying a case in which a student sued his school's board of directors because, having learned to read up to the level of lower education, the school awarded him a higher education diploma. Publications in this period and even those of the following decade seem to deal mainly with fraud practised by educational institutions rather than their students. This observation makes it possible to understand that academic ethics and their opposite, academic fraud, are strongly influenced by the historical–social context in which they are defined, making it difficult to understand what academic fraud is, the forms it takes, the representations that individuals have about academic fraud, its consequences, and its acceptance. The proliferation of terms used to refer to the same phenomenon does not make it easier to study it, either. "Academic fraud," "academic misconduct," "academic integrity," and "research ethics" are just some of the terms used in the literature and in the practices of higher education institutions.

2.1. Representations and Academic Fraud Practices

The forms of academic fraud are varied, and it is not easy to identify which practices are fraudulent. There is also sometimes a lack of consensus on certain practices, which is why some work has been devoted to analysing the social representations that educational actors have about fraud and its practices. Within fraud, we can include practices such as plagiarism, which consists of the appropriation of the work of others; fabrication, which may involve the falsification of information in an activity or also of identity; copying by using unauthorised materials or exchanging information

with a colleague; and many others [15–17]. Solmon adds obtaining copies of examinations through deceitful means and distributing them to other students [18]. The facilitation of fraudulent practices is in itself a fraudulent practice and is therefore also referred to in the literature [16,17]. However, the types of academic fraud are becoming more and more widespread, taking on nuances that make them difficult to classify [15]. As an example, Agud mentions a survey conducted by Guillermo Roquet: "inventing content; falsification; fictitious authorship; self-plagiarism or duplication; paid authorship; incorrect citation; missing citation; deliberate plagiarism; unintentional plagiarism; college plagiarism (the copying of fragments from various sites and presenting them in a unified work as one's own original creation); inappropriate paraphrasing; plagiarism by assignment (delivering the work of others); false citation; plagiarism by coincidence; invented citations; copying a translation; and, the one that affects us the most as teachers, copying and pasting" [15]. As a consequence, typologies of fraudulent practices are varied; in fact, some authors dedicated themselves to surveying them [2,19,20].

More recently in the literature, there is a preference for using the terms "academic integrity" and "academic misconduct," which encompass other problematic behaviours such as "plagiarism by staff and students, various forms of cheating, sexual harassment by staff and students in and out of the classroom, misuse of power, exchanging sexual activities for grades, and accepting money or gifts for grades" [21].

The diversity of nomenclatures and taxonomies will not make it easy for educational agents to identify clearly which fraudulent practices they should avoid and which behaviour they should prioritise, incorporating behaviour that respects academic integrity. The analysis of perceptions of academic fraud has therefore received attention from researchers [18,22–26].

The lack of knowledge about what is or is not acceptable, i.e., the representations that students have about the phenomenon, is one of the aspects that several authors suggest is at the root of their fraudulent behaviour [4,22,23]. In this regard, especially on the subject of plagiarism, it should not be assumed that students dominate the conventions and rules adopted in scientific work, which are sometimes unknown outside academia [4], hence the discussion on whether or not academic fraud should be considered in moral terms, i.e., judging the values of those who engage in bad academic practice [19]. Bloodgood et al. (2010) add that the attitude of students towards academic fraud practices is that of a game they enter in order to obtain high grades [23]. This can be related to peer pressure to adopt bad behaviour and the fact they may look bad if they do not do so, as everyone does [22]. Whether it is due to agreeing to enter the fraud game, not falling behind, or for other reasons, not all students see fraud as negative behaviour [13,16,18,19,24,26] or as a crime for which there are no victims [24]. Moral values weigh little on their propensity to report fraud committed by colleagues, with the distance between the complainant and the fraudster being what most favours reporting [26].

On the other hand, it cannot be said that academic fraud belongs to any particular area of science, with publications on students or authors in areas such as medicine [15,27], pharmacy [28], management [29], social sciences [30], humanities [6], technological areas [31], and mathematics [32]. This does not dismiss the fact that different trends for different areas can be identified, raising the hypothesis that there are different levels of self-efficacy in students from different fields of study [26]. Additionally, the phenomenon of academic fraud is not confined to a particular country, and the problem can be found in Anglo-Saxon countries such as Canada [3] and the US [24]; in European countries such as Bulgaria [6], Portugal [4], Spain [33], Switzerland [34], and Slovenia [35]; in Asian countries such as China [26]; and in other parts of the world such as Saudi Arabia and New Zealand [5], Australia [21], Israel [9], and Russia [36]. However, there may be particularities and some differences between countries in their greater or lesser preponderance, as shown by some studies [37], highlighting the influence of cultural factors and the characteristics of education systems.

2.2. Causes and Motives Leading to Academic Fraud

Several factors have been analysed and identified as motivating the occurrence of fraud practices, sometimes depending on the very conception and definition of the concept, as some authors maintain.

In this respect, some laboratory studies have been conducted, indicating that the propensity to cheat may depend on the absence of supervision, the expectation of gain, and the risk of being discovered. With this in mind, Cohn and Maréchal (2017) decided to verify whether the behaviour in the laboratory could be transposed to real situations, using the results of a controlled experiment where they recorded the tendency of the participants to cheat, and then compared those records with the teachers' evaluation of the academic conduct of each student [34]. They found that the correlation is strong, allowing trust in the results of laboratory studies, regardless of age, gender, nationality, level of education, parents' education, and cognitive ability. However, despite the relevance that laboratory studies can add, the factors that influence fraudulent practices have been studied mainly using questionnaire surveys [16,21,22,28,30,37,38].

Attitudes towards fraud seem to be predictors of fraudulent behaviour [16], and studies focusing on student representations reveal that students tend to rationalise these behaviours, minimising the effects of their wrong actions [22,39]. For MacGregor and Stuebs, rationalisation "is the cognitive process of making something seem consistent with (or based on) reason and is used by students to justify aggressive academic behaviours" [39]. In this sense, Beasley uses the term neutralisation, which he clarifies to be a justification or rationalisation for deviant behaviour, making it more acceptable, even if the perpetrator recognises that the action is wrong [22]. Hence, in the context of academic fraud, rationalisations can be considered students' justifications of their academic misbehaviours in order to achieve greater congruence with their personal values and with the ones that are accepted in society in general.

MacGregor and Stuebs considered four types of rationalisation that students tend to present to justify fraudulent behaviour: (a) the behaviour of peers, (b) ignorance due to the ambiguity of instructions, (c) unrealistic expectations of the instructor, and (d) minimising fraud as insignificant and unimportant [39]. Some of these rationalisations are recurrent in the literature, such as stress and the relationship with the teacher, but also include insufficient time to study, pressure to get good grades, ineffective prevention, difficult material, resentment towards the system that led them to it [16], fear of failure, and laziness [28]. In the Beasley study, the causes pointed out were: (a) ignorance of the consequences, (b) ignorance of the rules, and (c) neutralisation, i.e., rationalisation of their behaviour [22]. According to the author, the neutralisation techniques used by the students focus on the teachers': (i) condemning the condemned and changing the guilt, i.e., their ignorance is the fault of the teachers; (ii) the teachers' negligence, thinking that they do not care; (iii) incomprehension by the teachers; (iv) the teachers not giving good lessons; and (v) condemnation of the system. In a more recent paper, reviewing the literature and using the work of Sykes & Matza published in 1957, the authors list the following neutralisation techniques: (a) denial of responsibility for their actions, alleging overwork or ignorance of the rules of citation, for example; (b) denial that the fraud has consequences, arguing that it is not harming anyone; (c) denial of the victim, for example, not seeing the academic fraud as negative or blaming the victim, for example blaming the teacher for not being diligent in vigilance; and (d) condemnation of those convicted, diverting attention to others, often the teacher, for not having made material available, giving too much work, not helping, or not being understanding [7].

Other factors that do not constitute rationalisations include gender, and there are studies that reveal a greater propensity of males to commit fraud, either because they have greater acceptance of these practices [16] or because females tend to avoid risk [26]. Psychological factors such as perceived behavioural control and moral obligation [16], narcissistic traits sometimes attributed to millennials [30], Machiavellian traits [23], or selfishness and utilitarianism [38] reveal that the acceptance of fraudulent behaviour or the propensity to commit fraudulent practices is relevant.

But while some researchers find reasons attributable to students, others point to factors that are extrinsic to them. Indeed, as Barnhardt points out, academic fraud is a multidimensional construct [2]. Situational factors such as the opportunity to commit fraud are some of the factors that can increase the propensity to adopt fraudulent behaviour [18], which includes easy access to technologies such as the Internet, smartphones, smartwatches, and smart glasses, that create that opportunity [10]. This is

particularly relevant, as it points out that fraudulent acts can be more impulsive and constitute behaviour that is not entirely rational. It is also curious that the technology used in the game of not learning has the prefix "smart," reifying in students the notion that by committing fraud they are being "smart."

2.3. Measures to Combat Academic Fraud

The large numbers of students who admit to engaging in fraudulent acts or academic misconduct oblige teaching organisations to take measures to contain or avoid such practices. The students themselves, when questioned about the causes and motives for these practices, criticise the system and express the perception that teaching organisations should take action.

According to Gallant [8], quoting the works of Paine in 1994, and Whitley and Keith-Spiegel in 2002, schools tend to assume two strategies: (a) disciplinary, to ensure compliance with the rules, punishing those who break them and where the tone is often legalistic and confrontational [40], and (b) integrity, which acts on the character of students by seeking to internalise institutional rules as a pedagogical-formative strategy without dispensing with the first strategy's clear procedures that must be defined and followed [8]. In fact, as stated by Epstein, small acts of fraud can lead to disastrous consequences when there are only single, lenient procedures [1]. According to this author, the existence of formal procedures also has the function of avoiding false accusations of fraud in academia. Gallant [40], in turn, reiterates that the integrity strategy does not mean giving up discipline but rather using it as a tool and not as central policy.

However, it is increasingly argued that educational organisations should also take on the integrity strategy [8,18,40–43], and there is research that highlights the relationship between teaching–learning methods and the lesser or greater propensity for students to adopt bad academic behaviour. It can also be argued that this position reflects the point of view of teachers and institutions and not so much that of learners, who value disciplinary strategy more [44]. In this study, the authors found that the disciplinary strategy was most highly valued by students, who advocated measures such as heavier sanctions, parental notification, anonymous reports, and implementing a systematic policy. They also found that the measures considered less effective by the students were the existence of a code of honour, no strategies, compulsory ethics courses, and letting the teachers decide the sanctions. Still, regarding students' views about the measures to be adopted, it can be said that they have a more critical view of certain forms of fraud, advocating for heavier sanctions for these [2]. On the other hand, institutional practices vary widely, as demonstrated by the study on academic integrity policies, particularly for combating plagiarism, cited by Hodgkinson et al., where universities from 27 countries participated and where it is also pointed out that policies and measures tend not to be implemented systematically and consistently [10]. In fact, a still-preliminary report of the study acknowledged that among the main barriers in the fight against plagiarism were entrenched ideas adopted by the governments themselves and the access to new and now-widespread technologies [45] and thus also the difficulty of educational organisations to adopt policies and measures to combat it. Some research points out that educational organisations tend to adopt internal measures, and that unlike financial fraud, they tend not to involve the judicial system [17]. A number of preventive techniques have been surveyed, including the adoption of teaching, monitoring, and evaluation methods that have the effect of reducing the occurrence of fraud and that can be useful for universities to rethink their practices [10].

The adoption of teaching–learning methodologies that develop other competencies in the students besides the memorisation of contents allows for creating a favourable learning environment. This is intended to remove the focus on performance, where assessments are superficial, easy, or maladjusted to learning objectives and favour learning that is also superficial and motivated only by grades [41]. Presenting varied literature on the subject, Gallant takes up her 2008 thesis and maintains that environments that favour the learning of varied competences naturally reduce the propensity to commit academic fraud by developing in students the motivation to learn and the capacity to self-evaluate their knowledge, what they need, and how they can acquire it [41]. The adoption of

assessments that make sense to students also allows them to acquire an awareness of what they have gained from learning.

2.4. From Academic Fraud to Professional Ethics

The assumption that conduct, both ethical and unethical, in a school context can be transposed into the professional context or signal future unethical work conduct is sometimes referred to in the literature. However, specific research on this dimension of analysis is neither abundant nor recent. While not empirical in nature, Agud systematises the consequences that academic fraud practices may have on medical research and practice, affecting the fairness of future performance evaluations, and states that in terms of research, the publication of invented results and refusal to publish honest research can have serious consequences [15]. Honing et al. has reflected on scientific misconduct in the area of management, also with regard to publications and scientific work undertaken [46]. Other authors also refer to fraud committed in scientific publications [40,47,48], some addressing in particular industries dedicated to providing academic fraud services, such as contract cheating [49] or ghostwriters [13,14]. On the relationship between students' bad academic practices and their future professional ethics, some references may provide points for reflection. Although not the focus of their research, Alleyne and Phillips refer to some studies that support the existence of a relationship between the adoption of dishonest behaviour in academia and the subsequent manifestation of dishonest behaviour in a professional context [16]. Burrus et al. also found studies that make it possible to establish this relationship [12], while Bloodgood et al. raises the hypothesis that more competitive professional environments are more likely to trigger less ethical behaviours [23]. Studies by Cohn and Maréchal also make it clear that behaviours in controlled contexts, even laboratory ones, can be predictive of behaviours assumed in other contexts [34]. However, the occurrence of academic fraud does not always involve intentionality [2], which makes it possible to suggest further research into this under-exploited dimension. However, it is also worth recalling the work, for example, by Teixeira, highlighting the relationship between academic fraud and corruption rates [50].

3. Materials and Methods

In order to analyse students' perceptions of academic fraud, focus groups were used among undergraduate students from a school at the University of Lisbon, and conversation was stimulated among them, as suggested by Colella-Sandercock [3], to reveal their attitudes and involvement in practices such as plagiarism and other forms of academic misconduct.

Four focus groups were organised on the following themes: (1) representations and practices of academic fraud, (2) causes and motives leading to academic fraud, (3) measures to combat academic fraud, and (4) from academic fraud to professional ethics.

The researchers disseminated the implementation of the focus groups. The 34 students who volunteered to participate were distributed among the four focus groups as they arrived, targeting each group with a similar number of participants and heterogeneity in terms of gender and courses. Thus, each of the groups was composed of about 8 or 9 participants. A total of 22 girls and 12 boys from undergraduate studies in human resource management, sociology, and communication sciences, mostly in the second and third grades, participated.

The activity was carried out in four phases, each lasting 20 min, so that each participant would participate in the four focus groups and discuss all the planned themes. In all the phases, each focus group had two moderators, both teachers—one with the function of stimulating and moderating participation, the other with the function of recording in writing the main ideas of the interventions. Having previously obtained the authorisation of all the participants, the activity was recorded for subsequent transcription and analysis of the thematic content.

Care was taken in the preparation of the activity, which involved training the moderators to understand the objective of the work, the script, and the reception procedures in each focus group. Moreover, no information was given to students in the previous months and during the

implementation of the activity on academic fraud in order to avoid bias in the students' social representations. The moderators were careful not to express opinions, taking care to remain neutral and not to display verbal or non-verbal language that could reveal their position concerning what was verbalised by the participants.

A semi-structured script was prepared for each focus group with 5 to 7 questions. The following is an example of questions for each topic: (1) representations and practices of academic fraud (e.g., "What is academic fraud to you?"), (2) causes and motives leading to academic fraud (e.g., "What drives people to commit academic fraud?"), (3) measures to combat academic fraud (e.g., "What do you think should be done to prevent academic fraud?"), and (4) from academic fraud to professional ethics (e.g., "Is there a relationship between academic fraud practices and unethical professional practices?").

The study followed ethical principles in accordance with the American Psychological Association (2017) [51] with respect to human research (objective information, risks and benefits of the study, protection of personal data and guarantees of confidentiality, gratuitousness, and the possibility of abandoning the study at any of its stages).

The data collected were subject to content analysis [52]. A category system for coding the data was developed based on a bottom-up technique (i.e., emerging coding), with the theme as the unit of analysis; the sections with participants' replies that referred to the same theme were grouped together.

The content analysis was carried out with the help of Max-Qda software. To ensure the quality of the category system, two independent researchers coded 10% of the collected (randomly selected) transcriptions. The value of the interjudge agreement indicated a very appropriate level of reliability for the category system (k of Cohen for interjudge agreement: 90%).

4. Results

This process made it possible to identify 62 sub-categories whose designation reflects the content of the themes. These categories were grouped into 24 broad categories, which were in turn grouped into the four focus group themes. A total of 448 codifications were made.

4.1. Representations and Academic Fraud Practices

In terms of representations and practices of academic fraud, the focus groups made it possible to extract 14 subcategories organised into four main categories: forms of academic fraud (five subcategories);, unfamiliarity with academic fraud, forms of acquisition (two subcategories), and attitude towards the practice (seven subcategories).

When the results were analysed in terms of the four thematic groups, representations of fraud was one of the most discussed (with 183 references), as presented in Figure 1. The focus of the discussions was mainly on attitude towards the practice of academic fraud (104 references), showing evidence of students being keener to express their personal views on academic fraud than their views of what they understood academic fraud to be. Several attitudes were neutralisations such as the justification of students' actions (26 references), arguing, for example, "Some people have a very good memory and can write exactly the same words as there are in the handbooks. I see it can be considered as plagiarism, in an involuntary way," or claiming, "Signing for someone else is not that serious." Another neutralisation emerged as shifting the blame to the teacher (22 references), with participants stating, "It depends a lot on the teacher, because there are teachers who say they want a standard answer and others say they want us to process the information and give a critical opinion," that, "Teachers don't do anything, it seems as if they don't want to know," or even that, "When the teacher does not captivate or motivate students, it becomes much more difficult for the student to understand the subject. Then, in despair, he turns to cheating." Neutralisation through condemning the system (12 references) was also noticed among students' attitudes. The willingness of the students to report unethical behaviour was also much debated (23 references), although they tend to reject the idea of reporting: "It is a very cultural problem. If you ask that question in Portugal, most of the students will answer no, but in other countries students would say yes."

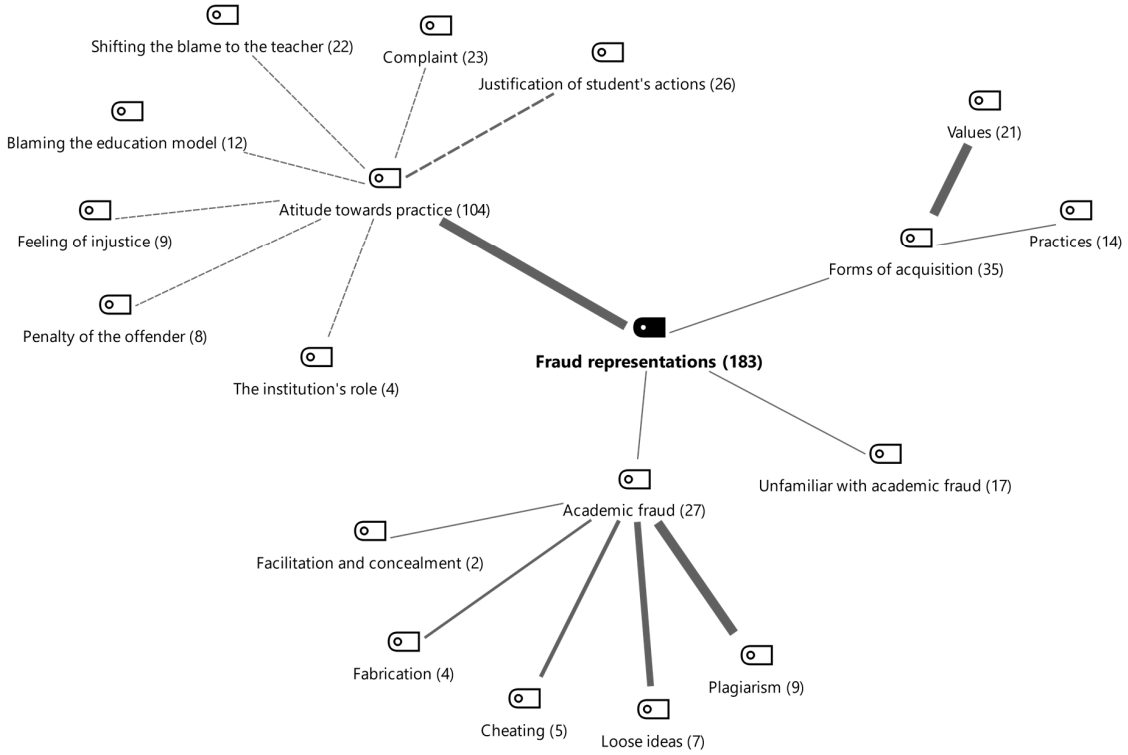

Figure 1. Representations and academic fraud practices: diagram of categories and subcategories.

In terms of forms of academic fraud (27 references), participants most frequently identified it as plagiarism (nine references), cheating (five references), and fabrication (four references), or stated loose ideas (seven references) on the topic. Regarding the ways of acquiring these practices (35 references), students tended to admit that academic fraud is a practice they have done since primary school and are therefore used to it, considering that it can affect their moral values when they see that practitioners succeed with the practice. We highlighted the views expressed in the category of unfamiliarity with academic fraud (17 references), which refers to the manifestation of the lack of information, which manifests itself in the lack of knowledge of the rules of scientific writing as well as the forms and characteristics relating to academic fraud on the part of the participating students.

4.2. Causes and Motives Leading to Academic Fraud

Regarding the causes and motives leading to academic fraud, the content analysis made it possible to identify 20 subcategories that were organised into six categories: practices in high school (two subcategories), personal attitude of the student (five subcategories), evaluation (three subcategories), teaching (five subcategories), social pressure (three subcategories), and ignorance (two subcategories).

The content analysis of the causes and motives leading to academic fraud (85 references), the synthesis of which can be seen in Figure 2, revealed that the education system is considered the main cause of academic fraud, including teaching (22 references), evaluation (13 references), and practices in high school (12 references). The personal attitude of the student (20 references) was not expressive when compared with the set of those three subcategories.

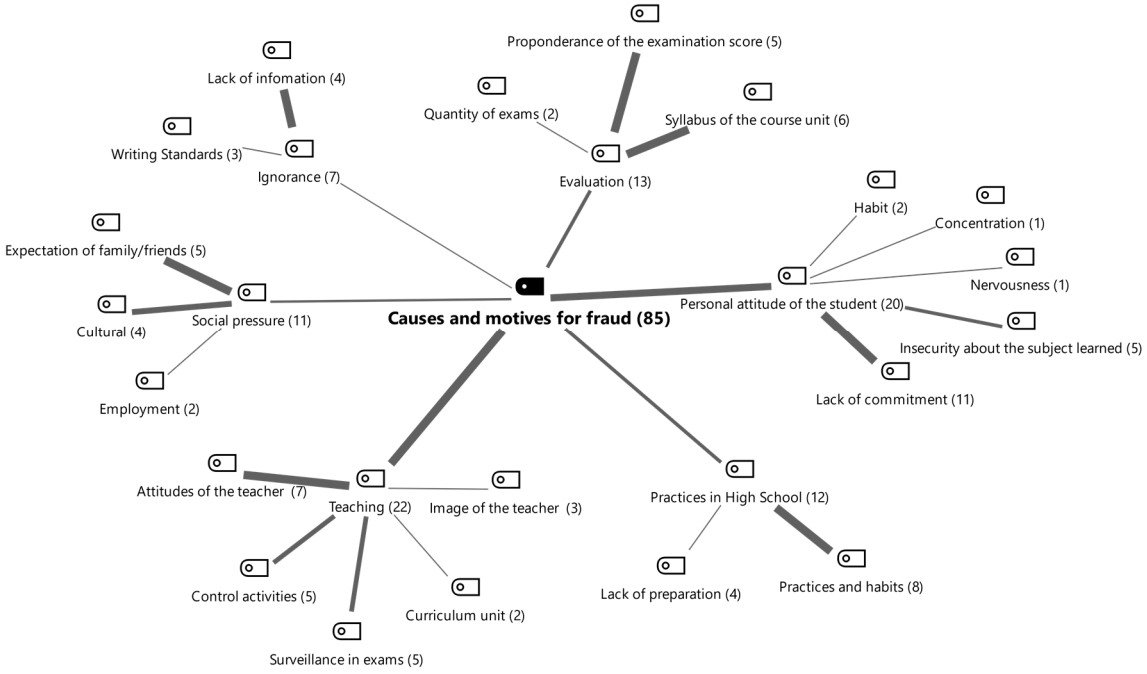

Figure 2. Causes and motives leading to academic fraud: diagram of categories and subcategories.

Regarding teaching, the students complained about the teacher's attitudes (seven references), considering that "Some teachers sometimes cause some instability, saying 'It will be difficult,'" or "There are teachers who want us to repeat word for word what they teach in class." Surveillance in exams (five references) was another reason, with students complaining about how teachers neglect that task—as one student pointed out, "Being at the computer, not paying attention to the room," and, "There are teachers who have seen it [students cheating] and they do nothing." Students also mentioned control activities (five references) where they referred to the relation with the teacher (that the teacher can be too close to some students, or in contrast that the teacher is too distant) but also their negligence in monitoring students' work.

Evaluation (13 references) as a cause of academic fraud in student's views derived from the syllabus of the course unit (six references) because of the extension and complexity of the subjects for evaluation; from the preponderance of the examination score (six references), defending continuous assessment; and from the number of examinations (two references): "If I have six exams I'm more likely to cheat."

Students also perceived that practices in high school were one of the causes of their unethical behaviour, because of the practices and habits they learned in that context (eight references): "In high school, we copy/paste an essay on the internet"; "I think cheating and plagiarism are something that comes from high school"; "High school essays are not very rigorous—we can copy and teachers do not give a damn." However, students also argued that high school does not prepare them for the demands of higher education, neutralising their responsibilities through the lack of preparation (four references).

Regarding the personal attitude of the student, a lack of commitment (11 references) was the main reason. Participants recognised that students engage in unethical behaviours due to laziness and because they do not want to study, among other similar reasons. Finally, it should also be noted that ignorance appeared only as a marginal reason.

4.3. Measures to Prevent Academic Fraud

When the academic fraud prevention measures were analysed, nine subcategories emerged, which were organised into eight categories: sanctions (five subcategories), software, information,

personal attitude of the student, teaching, evaluation methods, training (two subcategories), and role of the institution (four subcategories).

The content analysis of measures to prevent academic fraud (85 references), as shown in Figure 3, shows that most participants spoke about sanctions (24 references), the role of the institution (18 references), and evaluation methods (15 references). Reclassifying all the categories and the subcategories showed two major strategies: an integrity strategy and a disciplinary strategy.

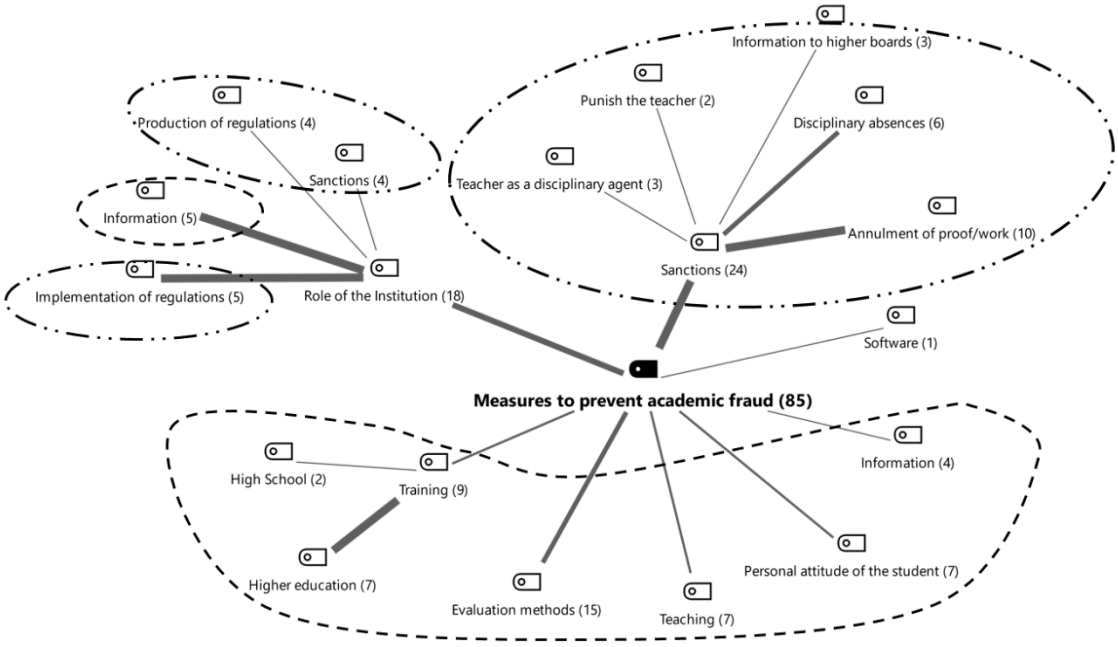

Figure 3. Measures to prevent academic fraud: diagram of categories and subcategories. Legend: - - - - integrity strategy and — · · — · disciplinary strategy.

An integrity strategy emerged from grouping together the categories and subcategories related to a pedagogical focus, such as the role of the institution/providing information, both subcategories of training, evaluation methods, teaching, personal attitude of the student, information, and software. A disciplinary strategy emerged from grouping the categories and subcategories with a disciplinary focus: the role of the institution/production of regulations, the role of the institution/sanctions, the role of the institution/implementation of regulations, and all sanction subcategories. Participants seemed to be more favourable of an integrity strategy (48 references) than a disciplinary strategy (37 references). As an integrative strategy, participants referred to mostly evaluation methods (15 references), such as reducing the syllabus of the course units or sustaining the effect of continuous assessment and training (nine references), either in high school or higher education. The sanctions participants most defended were annulment of proof/work (10 references).

4.4. From Academic Fraud to Professional Ethics

When the considerations concerning professional ethics were analysed, 14 subcategories emerged, which were organised into six categories: personal attitude of the student (three subcategories), the labour market (two subcategories), values (four subcategories), personal attitude of the teacher (three subcategories), training (two subcategories), and the role of the institution.

Regarding how participants perceive the relation of academic fraud to professional ethics (95 references), as presented in Figure 4, the category of the personal attitude of the student (31 references) emerges, mainly due to social perception (20 references), which may condition the student's attitude towards the practice of academic fraud. Some of the participants' statements reflected the kind of pressures they feel: "The one who cheats is the cool one"; "Being with someone else may not affect the

way I think, but it can make me act differently, for better or for worse"; "The message that is given to us is a good student is the one with good grades."

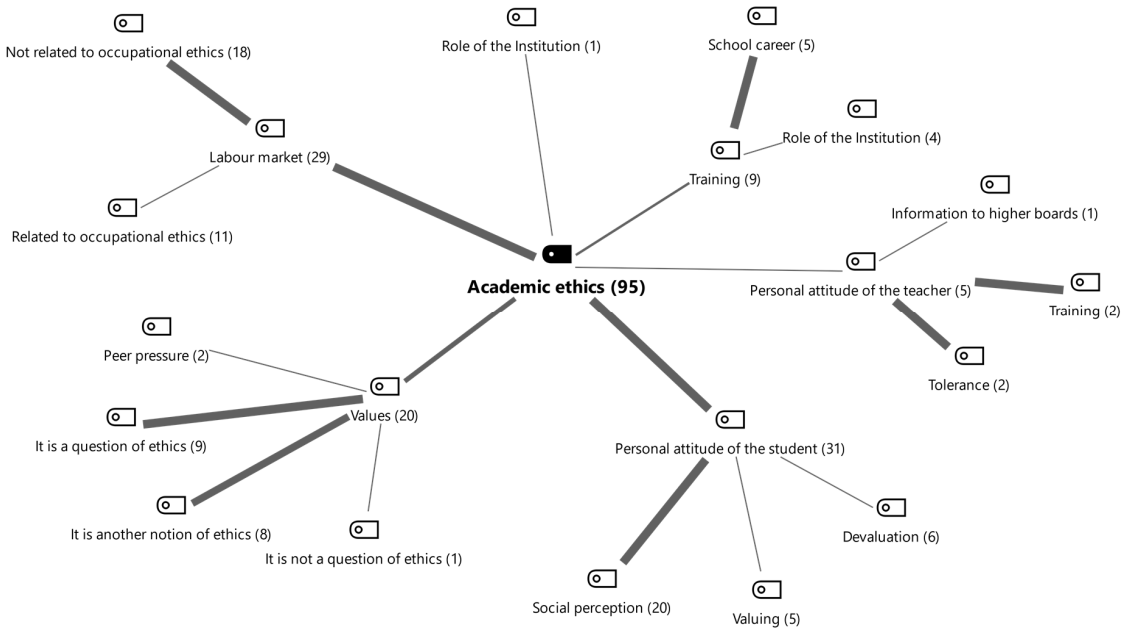

Figure 4. From academic fraud to professional ethics: diagram of categories and subcategories.

The labour market (29 references) was the second major topic that participants discussed, and their views were not consensual. Most frequently, they expressed that academic fraud is not related to occupational ethics (18 references): "I do not think that a student who commits academic fraud is bound to commit fraud in his professional future (. . .) maturity and commitment are different in this context"; "The best students are not always the best professionals." Others, however, do see academic fraud as being related to occupational ethics (11 references) saying, "If a student does it [academic fraud] on a regular basis, he will easily be able to sabotage the work of his colleagues or take advantage of it in the professional environment" or, "The best student is probably the one who studies and learns working methods."

Another major topic discussed by the participants was values (20 references). Some participants viewed the debate as a question of ethics (nine references), for example, defending that "Through academic ethics what we learn ends up being a basis for being in the job market, in the professional context in a generic way"; but other participants understood it instead as another notion of ethics (eight references), stating, "I think that a person who does cheat is much more capable than a person who just memorises. Now, as a team leader I want a person who gives me results," or even that it was not a question of ethics (one reference). Another participant did not believe it was a question of ethics, stating, "Fraud does not inevitably come from the lack of values, but from need. Necessity is the reason why a person/someone would not/does not respect values."

5. Discussion

The perceptions of the students who participated in this investigation are guided by diversity; they focus on aspects already mentioned in other investigations but allow us to account for its complexity, offering nuances that are still little explored. In effect, the analysis of these students' opinions allows us to resume the discussion of whether academic fraud should be stated in moral terms [19,23]. In fact, we found different notions of morality between students. For some, fraudulent practices are clearly condemnable and compromise science itself, while for others, they may be perfectly acceptable, meeting values that, in their opinion, are valued in the labour market. Furthermore, as these students expressed, and as other studies have identified [53], fraudulent practices are crystallised,

resulting from consensual habits throughout secondary school. Thus, the promotion of a culture of academic integrity must begin before higher education, promoting more and better information throughout the school path about good academic practices. This could be done, for example, by using the participation of higher education institutions; discouraging facilitating practices that do not encourage reading, such as studying through slides; and encouraging the completion of work using reliable sources. In higher education, actions can also be organised to clarify which values and practices should prevail and which are rewarded, where students openly discuss the consequences of adopting fraudulent practices. Potential employers and recruiters may also be called upon to participate, helping to change students' perceptions of the most valued values in the labour market. It should be noted that in this respect, the perceptions of students are sometimes contradictory. Some consider that the end justifies the means—achieving results is what matters most—but on the other hand, they separate academic ethics from professional ethics, i.e., they may believe that an individual who commits academic fraud will not necessarily commit fraud in a professional context, which is not supported by research [16], although this dimension has been less explored. According to these students, individuals have a blank slate when they move from one context to another and do not negatively judge colleagues who have achieved academic success through fraudulent behaviour. They tend to devalue fraudulent behaviour, a trend also identified in several studies [13,16,18,19,22,24,26,39]. Others make it clear that they would not trust some colleagues in a professional environment if they knew of their academic practices. Bad practices seem to be worthwhile, in a system where reporting is maligned by students and teachers [4,53,54] and where institutions seem not to have effective mechanisms to combat them. Identifying and giving a voice to honest students could contribute to diminishing the sense of impunity that exists among students with bad practices. On the other hand, although reporting could have a deterrent effect, it could endow the system with other problems, and it is difficult to distinguish legitimate reporting from reporting motivated by envy and the desire to harm colleagues regardless of their practices. Further discussion on its use could help to clarify its usefulness and the doubts it raises.

Alongside devaluation, students also tend to rationalise fraudulent behaviour by focusing on the role of the teacher or lecturer, as also highlighted in other research [7,16,22]. Both in the focus group that focused on the representations and practices of academic fraud and in the one where the causes and motives leading to academic fraud were discussed, this was the most prominent aspect (e.g., teachers were distant, suspicious, not understanding, and did not effectively monitor, among others). The study by Cohn and Maréchal, however, shows that some of the teachers' behaviours, such as the lack of vigilance, can in fact affect the students' propensity to commit fraud [34]. As for the type of teacher–student relationship, it is difficult to understand which characteristics may diminish the propensity for academic fraud. It is suggested that this is a topic on which further study is needed.

Ignorance is also widely referred to as a form of neutralisation or rationalisation of unethical behaviour [4,22,23]. In this research, ignorance was not the subject most discussed among students in any of the focus groups, although they commented that they were unaware of some forms of fraud, such as self-plagiarism, and the applicable sanctions. However, other forms—such as copying, forgery of signatures, and some forms of plagiarism—are known and used intentionally by students. Hence, the lack of commitment among students has also been pointed out as one of the main causes of academic fraud. Although laziness is mentioned in some of the studies consulted, the prominence of an aspect intrinsic to the student him- or herself is infrequent and highlights the present research. The use of focus groups, which facilitate the exchange of opinions between students without constraints, and the students' voluntary participation in them, may justify a greater propensity to admit intrinsic motives arising from students. It is not usual for students to justify their school failure in this way. In fact, in some studies on the subject, students, especially males, tend to attribute their failures to external factors such as teachers and tests, among others [55]. The sincerity of the participants obtained using this methodology makes it possible to suggest its use in future investigations focusing on this phenomenon.

Students' comments on pedagogical and evaluation methods, highlighted in the discussions around the representations and practices of academic fraud, the causes and motives for academic fraud, and the measures to prevent academic fraud, should not be forgotten. There is also some resentment among students on these issues. In fact, repressive measures based mainly on the application of sanctions to students caught committing fraud do not seem to have decreased the prevalence of these practices. According to students' perceptions, which call on institutions to define and apply regulations, students feel wronged when teachers close their eyes and colleagues who commit fraud go unpunished, so the application of sanctions cannot be neglected in order to avoid feelings of injustice and impunity. This is also how the values of academic integrity, so important in contexts where scientific knowledge is produced and disseminated, are affirmed. However, more educational and less repressive environments may promote less resentment on the part of students and tend to reduce the propensity to comment on academic fraud. This was an idea advocated by students who participated in focus groups and is also suggested in several studies [8,18,40–43].

6. Conclusions

This paper's main goal was to analyse Portuguese students' perceptions of academic fraud following a qualitative approach, and to that purpose, four focus groups were organised on the following themes: (1) representations and practices of academic fraud, (2) causes and motives leading to academic fraud, (3) measures to combat academic fraud, and (4) from academic fraud to professional ethics.

In the focus group on representations and practices of academic fraud, students were more eager to express how they felt about academic fraud and less keen to talk about what they thought academic fraud was. When the focus group was redirected to the students' representations, references to plagiarism stood out, but students tended to have general notions of what academic fraud is. This focus group allowed us to understand that academic practices need to be addressed in more pervasive ways for students who do not realise which academic practices they are supposed to follow and internalise. How establishments are teaching these practices must be discussed and deserves further study, because it seems to be ineffective. Students' attitudes regarding academic fraud reinforce this statement because they mostly are rationalisations of students' poor habits. These results may reveal that academic fraud practices may be internalised, which makes them much more difficult to eradicate when students are already in higher education. One suggestion is to initiate academic fraud combat when students move on to the second cycle of the Portuguese education system (corresponding to the fifth year of school), which is much more complex and demanding, with different disciplines and teachers, and could be an early stage for support and information on academic integrity. This could be a way to prevent fraud and stimulate academic integrity.

In the focus group on causes and motives leading to academic fraud, students tended to rationalise behaviour by blaming the teacher and the evaluation; therefore, their attitudes towards the education system are clearly not positive. This did not prevent them from assuming some of the blame themselves, namely admitting a lack of commitment as one of the causes. However, they also imputed charges to practices they acquired at secondary school, a more endemic cause related to educational structural deficiencies. Additionally, students did not stress ignorance as being one of the main causes, as shown by some studies, which contrasts with their diffuse representations of academic fraud. A possible explanation is that these students commit academic fraud because they do not know what academic fraud is, even if they do not rationalise their behaviour through their ignorance on the subject.

The results of the focus group on measures to prevent academic fraud reveal that these students prefer an integrity strategy (48) over a disciplinary strategy (37), contrasting with studies that have highlighted that the disciplinary strategy tends to be more highly valued by students. The qualitative approach of this research may provide one possible explanation because students' opinions were not induced by previous answers in a survey and instead emerged during the discussions. It is therefore possible that students' perceptions on measures to combat academic fraud are not significantly different

from those of the teachers and institution administrators, contributing to a better understanding of students' perceptions on academic fraud.

This article offers a better understanding of how students understand the relationship between academic fraud and professional ethics, which is rarely considered in research on academic fraud. In this regard, the students' opinions were not consensual and reported complex and diverse senses of reasoning. Some had a clear sense that academic fraud undermines science and has a relation with future professional profiles. Others did not perceive the existence of a relation between academic fraud and professional integrity, believing that people may act in a completely different way in a different context. Others also saw academic fraud practices as possible valuable traits once in a future professional context, arguing these practices can be seen as possessing problem-solving skills, for example. This diversity of perceptions shows a dissimilar sense of ethics among the student population that must be addressed, questioned, and considered when aiming to combat academic fraud.

Investigating academic fraud in a qualitative approach was effective in uncovering controversies, paradoxes, and meanings that are not available through a hypothetical–deductive approach, but empirical generalisations were not possible nor intended. Therefore, a limitation of this research is not providing general conclusions to the entire population. Another limitation is the sample composition, which was restricted to a single higher education institution and to social sciences students. A more diversified theoretical sampling, including graduate-level students from different institutions and scientific areas, could provide differentiated representations and introduce new perspectives.

The use of these four focus groups seemed to be useful in the study of perceptions on academic fraud, and they could be used to compare to teachers and employers' perceptions. Further studies can also explore the impact of news about and cases of academic fraud in the confidence in higher education institutions. Future research could also focus on other college-level students', such as masters and PhD students', perceptions, with more focus on academic fraud types that are more significant for research activity, such as plagiarism, inventing content, falsification, and many other forms of fraud that have become more salient.

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Article

Upgrading a Learning Context: Evaluation of Sintra's Educational Project

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Abstract: The changes observed in the school context demand new practices and impose new challenges to the operational assistants that, due to their relevant role in the educational environment, must be prepared and endowed with knowledge and skills to conduct their profession in a fully useful way. This is only possible through the promotion of their training and capacitation in a real work context. Through the European project entitled "Innovative Plans to Combat School Failure" which was implemented in Portugal, we assess the impacts of a training-capacitation action directed to operational assistants and explore the dynamics and influences underlying the learning process put in practice in the schools of the county of Sintra. This assessment conducted by a higher education institution (Iscte-University Institute of Lisbon) mobilized a mixed methodology-survey and focus groups with operational assistants and interviews conducted to school directors. We verified that a training activity conducted in the real working context potentiates the performance of these professionals, namely in terms of autonomy and adaptation to different contexts and duties, conflict management and cooperation, whose effects reflected on the organizational dynamics of the school institutions of the county of Sintra.

Keywords: learning contexts; operational assistants; training; evaluation; higher education; educational public policies

1. Introduction

Thinking about education as a process of knowledge acquisition and construction requires one to acknowledge that the learning process in a school does not simply occur in conventional teaching spaces such as the classroom but also outside of it. Thus, we should pay closer attention to all professionals that integrate the school organizations and act to potentialize the learning process of students as it is the case of operational assistants.

In the school environment, the operational assistants' functional contents are multifaceted, meaning that it includes the equipment's maintenance and the escorting and surveillance of the students. Aside from that, they are called to participate actively, flexibly and in an informed way in the school community by interacting regularly with the families and the academic and social environment that is involved. They are also the first contact that exists between the school and the environment itself, namely with the families as they are the ones who wait for them in the entrance gates. From the current Portuguese legislation (Law No. 184/2004) that defines the main duties of these professionals, we highlight the following ones: "(a) to participate with teachers in monitoring children and young people during the school's operating period, in order to ensure a good educational environment; (b) to clean, to preserve and ensure the good use of the facilities, the didactic and computer equipment's and other materials necessary for the development of the educational process; (c) to carry out tasks regarding customer service, escort the school users and control entries and exits from the school; (d) to

provide support and assistance in first aid situations and, if necessary, accompany the child or student to health care units".

Knowing that the role performed by these professionals in schools is becoming more relevant, their training and integration is imperative. On the one hand, such training is to grant the improvement of their performance and on the other hand to achieve an educational quality that respects the ongoing functioning of teaching organizations. In this sense, O'Connor et al. [1] point out that the agents in the work context should be prepared to better perform their tasks; however, this preparation must come from the development of specific and necessary skills to aim a change on the general behaviors and practices. That implies that organizations must be able to identify the problems/menaces and acknowledge that training and capacitating their agents continually is essential to answer the challenges that are presented to them. It also foresees that workers should be motivated or should demonstrate a predisposition to learn permanently and to adapt/change their behavior [2]. Aside from that, both the motivation to and the recognition of the training action should be considered as it is not always restricted to the training process. This means that the main wish of the trainees is to acquire knowledge that can effectively be put in practice.

Therefore, it is related to develop skills and to transmit knowledge that will prepare the operational assistants to become more effective throughout their functions (from the variety of duties to be performed by operational assistants, we highlight their participation and cooperation in supporting activities and socio-educational activities involving students and their families), preparing them for a variety of possible tasks they should perform, boosting them to assume more broad and demanding tasks in the future [2–4], thus promoting a school environment that provides improved learning and eases the process.

In this sense, we take as an example of analysis an innovative educational project of municipality focus named "The School Grows with Us", financed by the European Union and executed by the municipality of Sintra and developed by the Professors Association of Sintra. The reason for choosing this project is related to the fact that operational assistants are part of a group that is not always considered as an important element for change in the school dynamic. This project aimed exclusively to train and capacitate the operational assistants of the county of Sintra, which is the second most populated in Portugal, whose school network integrates 123 teaching institutes and 58,361 students (school year 2019/2020). Knowing that the effectiveness of the training activity is better succeeded when the intervention is evaluated, a group of external researchers from Iscte-University Institute of Lisbon, one of the most consecrated institutions in Portugal in the evaluation of educational policies, were called to implement and assess the project.

This said, the objective of this article is to put in evidence, opening with an evaluation supported by theory, what were the impacts of the training and capacitation action of the operational assistants and in which extent change was achieved in the sense of improving the educational context in the county of Sintra.

An Evaluation Based on "Theory"

Around the concept of evaluation, several approaches have been developed; however, there is no universal definition [5]. The conceptions around the evaluation differ significantly between authors, which translates in several approaches, definitions and perspectives of evaluation in the literature [6,7]. According to Gullickson [8], all parts involved in the evaluation process should understand in what consists evaluation and quality of evaluation. This understanding starts with its definition. The inexistence of a clear and consensual definition tends to allow for the development of diverse specific definitions in order to meet the needs. Thus, it is necessary to come up with a definition that allows one to distinguish the evaluation from other activities [8,9]. In this sense, Aguilar e Ander-Egg [5] affirm that the evaluation must come from a process of systematization and planification, from values and judgements performed by those who intend to estimate about a given program or activity, in order to identify and produce data and information that are relevant to judge

the value of that same program or activity, identifying problems or acting towards their correction, providing results and concrete effects [5]. It can also be said, according to Kosecoff and Fink [10], that evaluation relates to a set of proceedings that allow one to sustain the judgement on the merit of a program and provide information about their goals, expectancies and the foreseen results, the impacts and its costs.

Underlying the process of evaluation is the mobilization of a set of methodologies and steps that include activities that aim: (i) to estimate the broadness and relevance of the intervention; (ii) to ensure the accuracy of the diagnosis providing elements that grant a coherency and the conception of the intervention in the best conditions; (iii) materialize the intervention, doing an analytic and systematic approach that ensures the right usage of the environment and resources and the fulfilment of planning; and (iv) to identify and analyze the results from the intervention, determining if and in what extent changes were generated and in what extent it occurs exclusively from the intervention, questioning the efficacy and efficiency of the same intervention [11,12]. Notwithstanding this, the evaluation does not only circumscribe to achieve the objectives, but also allows the elements and entities involved in the different phases of the process to critically appreciate the work developed and the effective results and its impacts. Thus, from the evaluation one may expect judgments of value endowed with its utility [13,14]. This said, it was not intended that the evaluation of the project "The School Grows with Us" would be limited to prove the functional effectiveness of the training/capacitation program, but that it would be capable to assess and identify the reasons why the program worked, why it worked in a specific way and not in another at a given moment, if and how the functioning of the program can be improved. This means that, from evaluation, what is intended is to deconstruct the change mechanism, by importing the interactions between procedures and results [15,16]. This means that we are facing a type of evaluation that is inserted in the universe of the theory-driven evaluation [10]. In this type of approach, we use the theories that bring a greater explanatory capacity to evaluation, supporting the role it assumes for the comprehension of a certain social reality [17–19].

The work developed by Weiss [16] allows for the definition of a theory of change as an explanation to "how" and "why" a program works. The theory of change is then related to a cumulative and systematic analysis of the relations that are established between contexts, activities, and results [18,20], to ensure the success of the program. Some authors refer that the use of the theory of change is controversial when it comes to evaluation. If, on the one hand, some are opposed to the use of a specific theory for the program to be evaluated, because this approach implies validation and proven methodology, others state that just one theory of change is not enough in an evaluation, since it does not integrate a counter factual analysis. Nevertheless, theories of change have been used in evaluation and some evaluators have shown how useful it can be [21].

The understanding produced around the evaluation based on theory considers that this provides information that are not easily achieved through the implementation of traditional approaches. For this reason and because it aligns and/or adjusts the implicit and explicit theories that mediate from the diagnosis through the delineation of the objectives to achieve, the strategies to mobilize, the activities to be carried out and the stages in which the program is implemented, the theory of change assumes an important tool for planning and evaluating educational policies.

Enabling the involvement of the different interested stakeholders in the planning of change [15,20,22], "the theory contributes for the existence of a more transparent relationship between the evaluators and all those who, in some way, are involved in the evaluation process, allowing to better understand what is or may be at stake in that same process" [23] (p.29).

An evaluation based on the theory-driven evaluation is thus able to identify what to assess and establish a set of guidelines that provides organizations/policy makers an orientation on when and what to evaluate [24,25]. However, the construction of that information comes from a process that requires a high level of rigor implying that there is ample scientific knowledge [26] about the object to be evaluated in order to ensure the viability, efficiency and effectiveness of the implementation.

In addition, the impartiality in an evaluation process must always be preserved, even if the evaluators intend to establish close relationships with all stakeholders [27,28].

The theory-driven evaluation stems first from the analysis and characterization of the context to be intervened/evaluated, pointing out the problems to be solved and the factors underlying them—indicating the eventual relationships and/or processes that are at their origin—and signaling the main actors involved. This is followed by an assessment of the coherence of the activities inserted in the program, which can generate causality, becoming then expectable that it can lead to the creation of a new context—which corroborates the theory. In the last phase, the change that was firstly projected tends to be reflected in the modification of the problems that were identified. Thus, in the case of Sintra, the factor/problem laid in the incipient level of technical and professional preparation of the operational assistants and in the lack of specific and necessary skills for the performance of their profession in a full educational logic and not only in the playground surveillance.

The training needs that were identified in the schools of Sintra—as the Municipality of Sintra carried out a survey of the training needs of the human resources of the municipality's educational institutions—are not an isolated case. On the contrary, it appears to be a deficiency in most Portuguese educational institutions just like it is evidenced in the most recent literature. Some authors [4,29] have addressed this reality, stating that the training provided to operational assistants has been insufficient to teach them specific skills for the tasks they perform, which perpetuates a weak social image of the profession and makes it impossible for them to be active agents in the educational process.

The theory-driven evaluation implies a construction of a hypothesis to be tested in the case that: (i) the level of performance of the operational assistants can be optimized; (ii) the training and capacitation of these professionals prepares them for the performance of new and more demanding duties; (iii) the transmission of content and learning process is favored if performed in real work context.

Thus, from the evaluation that was developed, it was evident that a demanding learning process capable of deeply changing the functional profile of the operational assistants could not happen "in a vacuum", and should be as directly as possible linked to the concrete experiences of the real work, in order to allow the receptor to relate the contents of the training with his/her personal frame of reference—this is marked by a set of experiences, involving diverse interactions with other agents from the inside and from the outside of the school organization [30].

In this sense, considering the learning context implies starting from a model that related the receptor to the content, and the context to the learning event. Although some authors warn to the inexistence of a consensual definition of what constitutes "context" [31], from the multiplicity of understandings built around the concept of learning context, it can be essentially defined as a set of circumstances that are relevant when someone needs to learn something [32].

This said, training in a real work context came to support the notion that it is easier to learn or integrate new ideas through what is already known or practiced [1]. Training in the workplace is not limited to the easy identification of factors that stimulate or block the achievement of the intended objectives. In this type of training is valorized a set of given strategies, actions and relationships between the trainers and trainees which potentializes the learning process.

Nevertheless, to intervene in the core of the competencies of the operational assistant implies the acknowledgement of the needs that were previously identified and the need to build a model that is consistent with a strategic plan of action in order to address the institutional deficiencies. The concept of competence encompasses the behavioral and action dimensions. However, understanding that the competence is the output requires comprehending that it is influenced by values, self-concepts, personality traits and motivations. Thus, competence is understood as the set of qualities and professional behaviors that mobilize the technical knowledge and allow action to be taken to solve problems, stimulating a superior professional performance aligned with the strategy of the organization [33].

As the main conclusions, we refer that: (a) a training/capacitation program, to be well succeeded, must combine the institutional needs with what the employee wants and needs to learn; (b) it is not

sufficient to intervene uniquely with the professionals but also to act in the school organization in order to enable them to involve at another level, develop other activities and achieve other results; (c) a school organization benefits from the articulation and cooperation between different professional groups.

In general, this article is based on the effects of an evaluation of a specific educational project, conducted by a team of researchers/evaluators from the University, that aims to highlight the possible frameworks of the learning context as a promotor of multiple, modal and interactional ways of acquiring knowledge and competences for the plurality of the actors involved.

2. Materials and Methods

2.1. Method

The evaluation (*ex-post*) of the impacts of the training-capacitation was essentially related to the answer of two elementary questions: (i) in terms of the trainees' learning, to what extent were the training-capacitation objectives achieved?; and (ii) to what extent has the achievement of these objectives resulted in changes or improvements in the performance of the operational assistants and in the organizational and institutional dynamics? Thus, we aimed to identify if there was a transfer of acquired knowledge to the professional performance.

We adopted mixed-methods [34] as the best way to assess the impacts of the project "The School Grows with Us". The use of mixed methods in terms of evaluation allows one to understand the internal and external influences and the various elements that characterize and/or interfere with the process of change [35,36].

2.2. Techniques and Procedures

In a first instance, a survey was produced and applied to operational assistants.

In the survey, we explored the operational assistants' perceptions: (i) about their participation in training actions and the contribution they consider the actions had to the improvement of their qualifications and to the performance of their duties, as well as their intention to integrate future training actions; (ii) regarding the importance of their profession, the underlying challenges and the performance of their duties; (iii) in terms of the work environment and labor relationships. The approach to the training-capacity action was supported by the analysis of the operational assistants' perceptions regarding a set of skills, which comprised their knowledge, behaviors and attitudes, and the program's contribution to the acquisition and/or increase in these skills. These skills integrated four spheres of analysis—Knowing, Being and Doing and also other Strategic Competencies. These skills which were grouped in the following categories:

(i) *Information and communication*, regarding the ability to analyze, understand, produce and transmit content in the different contexts in which the respondents operate.
(ii) *Technical knowledge*, including knowledge and application of techniques and practices, taking into account the various plans of their professional context.
(iii) *Technological knowledge*, regarding the use and handling of technological equipment.
(iv) *Personal development, autonomy and adaptation*, reporting on the development of self-confidence, emotional and behavioral self-regulation, knowledge and compliance with their work plan and the ability to adapt to new duties and contexts.
(v) *Interpersonal relationships*, focusing on the interactions that operational assistants establish in different contexts with the school community, in work relationships, behavior and intervention dynamics.

The second phase involved the conduction of semi-structured interviews with the directors of the school groupings and to the responsible for coordinating the training-capacitation program, member of the Association of Teachers of Sintra, the entity responsible for implementing the training-capacitation action. The coordinator played a fundamental role, both in structuring and

dynamizing the training-capacitation action, and through the articulation and mediation established between operational assistants, educational institutions and the Municipality of Sintra. The interviews with the directors of the school groupings, focused particularly on the identification of the changes verified in the operational assistants (e.g., at the individual and collective level and the development and applicability of professional skills and the changes in the relational dynamics); the effect of training of operational assistants in the school dynamic (e.g., effects on ways of action and intervention of operational assistants, capacity for problem solving in different contexts). Regarding the interview with the coordinator of the training-capacitation action, it was based on the identification of the mechanisms, difficulties, mobilized strategies related to the practical context of the training-capacitation action and also on the impacts observed on the trainees and the school dynamic during the program.

In order to analyze in more depth the dimensions of a more subjective nature and considering that these are more easily identified in environments that promote the collective sharing of perspectives and experiences, the last phase included the conduction of focus groups, each composed of operational assistants pertaining to school groupings involved in the project.

For the evaluation, the focus group technique proved to be quite appropriate, as the operational assistants were not only the object of the study, but also active elements in the process. In addition, this technique allowed us to identify possible disparities between the knowledge, practices and attitudes [37] of the operational assistants. Therefore, it made it possible to assess in greater detail the possible changes that occurred. Thus, the focus groups were carried out in order to acquire new data, by exploring the impacts and changes perceived by the operational assistants, after their participation in the training-capacitation action. It can be said that the focus groups were essentially based on three main dimensions:

(i) The training-capacitation action itself—essentially addressing aspects related to the relationship and communication with the trainers, suitability and relevance of the syllabus for the real work environment. We also tried to understand how and why participation in the training and in the developed activities improved their professional performance and in which levels an immediate performance was verified. Concrete examples were shared in terms of the practices and strategies used.

(ii) The profession and the work environment—particularly addressing aspects such as changes in the ways of dealing/managing the different situations or problems inherent in the work context and/or that may arise from there, relationships and articulation with other professionals in the education environment and autonomy or freedom to carry out their functions.

(iii) Professional development and future prospects—addressing aspects related to personal and organizational investment to improve their professional performance, as well as the way in which the contributions of the operational assistants were incorporated into the organizational dynamic of schools, and changes (positive and/or negative) coming from this integration.

2.3. Sample

The survey was applied to 109 operational assistants from 8 school groupings in the municipality of Sintra (out of a total of 20 school groupings in the municipality). The criteria underlying the selection of the school grouping was due to the fact that the schools completed the training-capacitation action in a period considered appropriate to carry out the assessment of individual and organizational impacts (completed at least 3 months after the training-capacitation action).

The criteria for selecting the operational assistants to inquire and participate in the focus groups was related to the completion of the training-capacitation action. Once the 8 school groupings met this requirement, the sample was selected randomly (random sample). Three focus groups were performed, each composed of 8 operational assistants pertaining to 3 out of the 8 school groupings involved in the project.

The delimitation of the number of interviews and focus groups to be carried out was conducted a posteriori due to the proved saturation of the collected information [38,39].

2.4. Data Processing and Analysis

The survey was carried out via an online platform. The treatment of the data obtained was carried out through a statistical analysis program—SPSS—and in the case of open type responses, content analysis was performed. The information collected through the focus groups was also submitted to a content analysis process.

The data collection and its treatment, respected the guarantee of confidentiality and anonymity, which was followed by an encryption process for all data/content that could identify the respondents.

The survey conducted to the operational assistants proved to be very useful in understanding their assessment of the project; in direct articulation with the focus groups, it allowed an assessment of the personal, interpersonal and group impacts on the operational assistants. The interviews conducted to the school directors enriched the evaluative framework of Iscte's researchers by allowing them to understand the organizational changes in the school context resulting from the changes in practices by the operational assistants.

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3. "The School Grows with Us" Project: An Innovative Local Educational Policy

The project "The School Grows with Us" is part of a larger European project named "Innovative Plans to Combat School Failure" that aims to promote the students' success by improving the school environment through training and capacitation actions directed to the operational assistants. The project, aligned with the Smart, Sustained and Inclusive Growth, is part of the 2020 European Strategy and comprises the principles that consecrate the economic, social and territorial development to promote Portugal between the years 2014 and 2020 (Portugal 2020). This project, presented under the Program of Action of the Pact for Development and Territorial Cohesion in the Metropolitan Area of Lisbon, aims to reduce the rate of primary and secondary school students with negative results, as well as to reduce the retention and drop out rate. In this sense, the project "The School Grows with Us" promotes the combat to school failure in complementarity with the plans to improve the Educational Territories for Priority Intervention (TEIP) and the National Program for School Success (PNPSE).

As it is a public local initiative, it expresses a change in the political-educational paradigm, by placing adult education and training as one of the priorities for the local government programs. Due to the territorial extension and the socioeconomic diversity of the county of Sintra, the intervention combined different educational territories and specific areas of intervention which were defined according to their characteristics and main needs identified.

In addition to expressing a deep change on the governmental educational politics in Portugal resulting from the empowerment of the counties, the innovative character of the project consists of promoting the role of the operational assistants in schools. This promotion assumes a greater relevance in the construction of new educational projects in their mission to promote a safe and educational space of quality for all: students, professors, parents and operational assistants. Thus, promoting the improvement of the students' performance necessarily involves the improvement of the performance of the operational assistants, which observe and act in the school compound, especially during recess, where professors and parents are not present. In this sense, this project came to open the horizon to the combat of school failure by valuing the role of a professional group that is not usually considered. Essentially it is a matter of transforming them from mere "surveillants and cleaners" into effectively relevant educational agents.

Regarding the profession of operational assistant, which has been modified through changes in the political-educational environment, new practices are being added, but new responsibilities,

requirements and challenges have also been passed over. As it is an occupation that is easily associated with low levels of qualification and low income and to which persists a lack of attention to their training needs, a project specifically oriented to these workers is an innovative aspect because of its broadness and an intervention structure was created to cover all operational assistants of the schools in the municipality of Sintra.

By listening to the school groupings' representatives, it had been possible to identify a priori a set of essential dimensions for priority intervention: (a) inclusion (of cultural and religious minorities and of students with health special needs); (b) conflict management (in the inter-relational aspect between students, operational assistants, professors–family); (c) teamwork; (d) intervention in the context of the school library, learning centers, sport pavilions, cafeteria, outdoor spaces and other areas related to the school institution; (e) assertive communication; (f) first-aid; and (g) absenteeism by sick leave. Thus, to intervene near the operational assistants, we sought to increase their levels of awareness and skills for collaborative work, to develop literacy skills, to capacitate for a context of change, exercise self-reflection and continuous assessment. During the training and capacitation actions the operational assistants were helped in the sense of acknowledging their contribution to the educational environment and to comprehend their potential not only as professionals but also as human beings.

The training component lasted 30 h and focused on sharing the trainees' professional experience and personal perspectives regarding pre-defined subjects. This modality allowed in a later phase, to approach the belief and values system and the different types of families and students.

The capacitation aspect which lasted 50 to 80 h—divided into 14 modules, each corresponding to 2 h of theoretical-practical classes and 2 h of autonomous work in real work context under supervision—deepened the interaction techniques and communication through the mechanisms of personal and collective development. In addition, the capacitation aspect focused on language issues, approaching aspects such as generalizations, distortions, omissions, and prejudgments in order to develop a coherent and contextualized discursive practice. Regarding communication practices for conflict management and other non-violent communication mechanisms, it has been possible to approach the emotional management and its dynamic. These were the main deficiencies found in the diagnostic phase, which proved to be worthy of special attention due to its influence at the level of the relationships and interactions between the operational assistants and the students and their families. It was also addressed the digital financial literacy and the importance of lifelong learning always associated with practical exercises as a pedagogic strategy.

Through a dynamic of teambuilding, which lasted 6 h, it had been put in practice a cooperation game aimed to improve communication and the development of necessary skills not only directed to their professional reality but also to the personal as social life. (It refers to a group dynamic that aimed to gather, at the final phase of the training-capacitation program, the different groups of professionals from each school grouping of the county. Professors, members of the directive board and operational assistants were present. This dynamic aimed to promote a spirit of cooperation, reflexive capacity and self-evaluation, the construction of a collective understanding that "School Grows with Us", as well as a joint reflection about the challenges of change). Lastly, the trainees were capacitated to act in emergency situations by being trained for basic-life support so they can act in cardiorespiratory arrest and/or resuscitation. It is important to note that all measures were followed by collaborative tasks and the physical and psychological well-being was also approached through mindfulness exercises. (It is related to an activity that aimed to focus on body and emotion consciousness as a skill to develop. It is a matter of understanding the body, "body-scan", to promote the exercises of listening, feeling, and understanding it). The trainees were evaluated throughout the program based on oral presentations.

4. Design and Organize the Learning Context

Approaching the learning context implies knowing that several actors are present in it. A project of learning in context requires a prior and solid preparation that brings together professionals from different areas of action: the institution, promoter of the project; the entity that carries it out; and the

evaluators. Thus, after identifying the field of intervention, it is necessary to include professionals that are qualified to train groups or subgroups, assuring adequate learning initiatives.

Organizing the learning context implies the prior identification of main skills which includes the adaptation capacity, not only of the strategies and resources to mobilize, but also of the professionals and the targeted audience of the project.

Putting in practice a learning context of this nature, it is comprehended that there is a plurality of modalities in which the learning context occurs. This allows for the discussion of the plasticity, broadness and multidimensionality of the concept of learning context. The learning context is rarely unilateral or linear as it assumes an inter-relation between all the intervenients in the process. In this sense, the importance that the context plays in the different phases of the assessment must be recognized, and must always be considered not only for the decision-making process but also in the design of the assessment and essentially in the analysis and interpretation of the results. The internal and external context in which the evaluation is inserted is fundamental, because its understanding allows one not only to identify needs for adjustments to the research design in order to consider the specificities of the object to be evaluated, but also to explain the relationship between processes and results [35]. In this sense, we understand that the learning context is intrinsically associated with the evaluation itself. That is, the promoting entity, in this specific case, the municipality of Sintra, evaluates the quality of the proposal, the researchers evaluate its execution and take their conclusions, the operational assistants evaluate the contribution of the training action to which they were submitted. This way, the interrelation in the learning context takes place between the parties involved and it contributes to the assessment complementing it, even if in different ways.

In order to illustrate this statement, see the Figure 1, which demonstrates the dynamic related to the learning process in the real work context. From the objectives, the project design and passing by the development of its implementation, we outstand the power of initiative and action of the institutional/political organizations that suggested the project. They are the ones who hire the higher education institution to implement the project evaluation, specially near the target audience: the operational assistants.

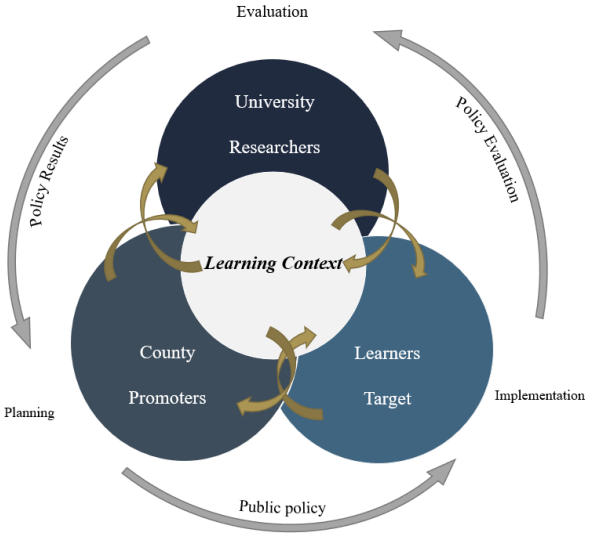

Figure 1. Inter-relations dynamic diagram of the learning context in the evaluation of public policies. Source: Authors.

In the phase of the evaluation, the necessity to adapt to a double context, on the one hand to the context where it was developed and on the other hand to who was involved, is revealed. In this sense, we registered a learning process both by those who were responsible for the evaluation, and by those who were the main object of this traning-capacitation action. In a third phase, the presentation of

the results coming from the researchers' analysis are the same reported to the institutional organism promoter of the project. This last reflects upon the evaluation and the results of the project that it decided to apply, gauging its quality and suggesting changes for a new project development, if needed. Thus, the learning context assumes the function of a central engine that promotes and consubstantiates the management of an educational project such as this one. It is then considered that the learning context touches all the intervenients, even if in different moments and not only those for whom the program was designed in first place.

5. Results

5.1. "The School Grows with Us": Impacts from the Training-Capacitation Action

The first objective of the training-capacitation action is to generate a change in the knowledge and behavior plan, in order to achieve a level of development that surpasses the initial stage to be reflected in the work practical context. The success of the training-capacitation action is partly due to its flexible and personalized character. It was conducted not only by taking into account the abstract needs inserted in the intervention plan, but was also adjusted to the trainees, considering their criticisms, interests, availability and difficulties, which triggered a greater receptivity and therefore greater productivity and better results.

The contribution to the increase in the levels of literacy (Figure 2) of the operational assistants was notoriously essential in the domains that are considered indispensable for the performance of their functions. These domains include the sphere of information and communication (through the development of the analysis capacity), the sphere of understanding, production and content transmission in the different contexts of action that are included. This last domain is reflected, for instance, in situations of communication with foreign students and their families, escorting the users of the educational institution or even to know how to express their opinion (64.2% indicated that this was of some to great contribution) and communicating both orally and by writing (58.7% and 50.5%, respectively, stated that this was great contribution).

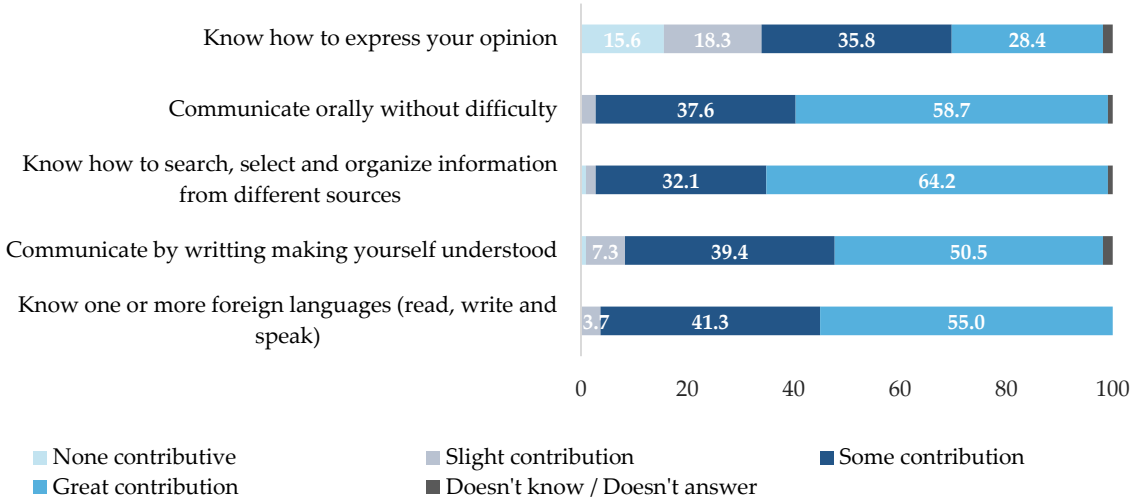

Figure 2. Contributions of the training-capacitation action for the acquisition of information and communication skills (%). Source: Survey to the operational assistants.

The acquisition and/or reinforcement of technical-professional knowledge, such as the application of basic life support techniques and the assistance to students with special health needs, the awareness for the rights and duties of all users of the school—knowledge indispensable for carrying out the operational assistants' day-to-day job—are identified by them as new and important acquired skills. It should be noted that 58.7% of the surveyed operational assistants referred that the training-capacity

actions contributed significantly to the management and adaptation to the responses they are faced with daily, resolving different situations fairly and in accordance with the norms (Figure 3).

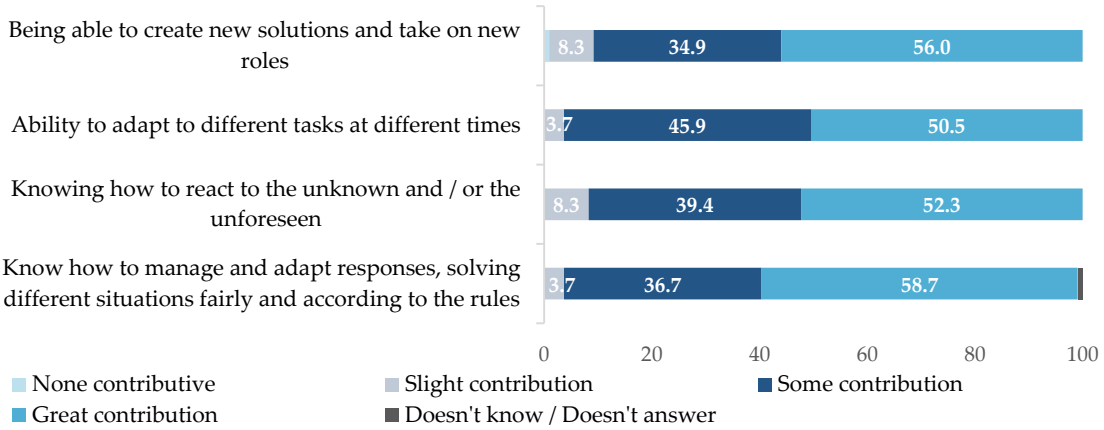

Figure 3. Contributions of the training-capacitation action for the acquisition of autonomy and adaptation skills (%). Source: Survey to the operational assistants.

Regarding practices and care techniques, 60.6% reveals that it had a major contribution. Regarding technological knowledge, the development of technical skills is also identified (69.7% indicates that it is already an acquired skill). When rotation between posts is necessary, this often leads to constraints in the management of employees by the school directors given the difficulties faced by a large portion of operational assistants in the handling of technological equipment. By focusing on this matter, the training-capacitation action also made it possible to demystify some concepts associated with services where the use of technological equipment is constant, such as the stationery store or library, whose operational assistant who works there tended to be perceived as more competent. Additionally, on the other hand, it allowed for reversing the resistance or fears of operational assistants who did not intend to be deployed to these services because they associated them with requirements for knowledge and skills they did not have.

Although it is pertinent to reinforce or deepen some areas of technical and professional knowledge continuously, guaranteeing the progress and updating of contents, the knowledge increase of operational assistants in these areas has led to the enhancement of their adaptability and their confidence levels and participation, which resulted in better performance both individually and institutionally.

The range of changes observed is more visible in what refers to the acquisition and/or development of personal, behavioral, and social skills, in comparison, for example, with techniques. By participating in the training-capacitation action, facing it as an investment for their personal and professional growth, the operational assistants faced "transformative" learning. In this sense, it resulted in the (re)thinking of a new set of practices and behaviors diverging from what these professionals had being shaping according to the situations they experienced during their work performance and thought would be the most appropriate. The impact of this learning was perceived by the operational assistants when they identified deep changes in their ways of being, thinking, acting, and feeling, transposing a more valuable look at themselves and the jobs they perform.

The changes in the communicational and interventive dynamics and the promotion of a greater commitment to the harmonious resolution of conflicts caused effects not only in the relationship between co-workers—previously involved in situations of friction, disagreements or intransigencies—but also in the work environment and interpersonal relationships that are established daily with the other actors that integrate the school context. They also demonstrated a greater cordiality in the contact with members of the school boards, with students and with the families, which consequently impacted on the image of the school.

During the evaluation, the operational assistants and the management of the school groupings noted the adoption of a posture oriented towards cooperation, showing a greater openness to share perspectives, experiences and knowledge, which describes a scenario of increased proximity and availability—even among elements that had conflicting relationships. In this sense, among the verified transformations, it is worth mentioning a greater capacity for analysis and to shape their reactions when facing unforeseen or unexpected circumstances and (or in anticipation of) specific problems, for which the application of self-control techniques learned from the training-capacitation actions demonstrated its efficacy. The expression of dissatisfaction became more thoughtful, timely and polished. These acquired skills are extended to other social contexts in which the operational assistants are inserted, thus having an impact on their family relationships and on their emotional well-being, as they are more able to dissociate themselves from possible problems caused by and at work.

If prior to their participation in the training-capacitation action the operational assistants did not express an interest in presenting their points of view, or suggestions for improvement, or simply were not able to do so, they acquired a greater predisposition for proactivity and criticism and initiative, also showing a greater capacity for decision making and, as a consequence, greater autonomy. This evolution is noticeable by observing that these professionals put into practice the knowledge and techniques acquired in the training-capacitation action, revealing the transfer of learning to the workplace, as intended by the municipality of Sintra.

As it is a professional group that often feels less valued and that perceived participation in training actions exclusively accessible to restricted professional groups and/or with higher qualification levels, attending a training action unique and exclusively designed for them generated a feeling of appreciation, enhancing its performance. This is a significant aspect, since for many of the operational assistants this training-capacitation action was fundamental, and for some even more so as it was the only one they benefited from or the most extensive since the beginning of their career. The training-capacitation action contributed, on a large scale, to the collective increase in self-esteem, satisfaction and motivation for the work environment and for the individual recognition of their own capacities and aptitudes. In this sense, it also allowed the school boards to better understand the capabilities and limitations of operational assistants, favoring a balanced management in regards to their allocation in services more oriented to their profile—which, in complementarity with the assignment of new (or more) tasks, came to be seen by these professionals as a vote of confidence by the school board. The changes in the organizational dynamics of the schools also allowed us to reinforce the sense of tolerance and a more objective view on the organizational and institutional (in)capacities, by awakening to the understanding of the need for flexibility of the operational assistants and their sense of usefulness, combined with the understanding that their absences from work have an impact on the functioning of schools (something that only in the medium to long term will it be possible to assess widely).

On another level, the development of the teambuilding dynamics that integrated some members of the teaching teams and the school boards provided, as main contributions or benefits, the creation or strengthening of ties. Because it was so enriching, it led some of the school groups to consider the future reproduction of the activity in a model that maintains the involvement of both professional groups, in order to promote or maintain an environment of cooperation and mutual appreciation.

The assessment revealed the high importance that the attributes of the profession can have for operational assistants themselves, and that monitoring the growth of students, the assistance they provide and the connection they create with them are the main reasons why they perform the profession, them being those who most directly recognize the work they do in schools. This is true even if it is a profession that is associated with multiple duties and responsibilities, but with reduced salaries, which brings to mind the centrality of work in society and its identity and integrative functions, and its role in reaching satisfaction and personal and professional fulfillment.

The constraints felt at a time of a global pandemic caused by COVID-19, implied some changes to the format initially thought for the training-capacitation action, impelling periods of confinement and the use of digital means for its implementation. Nevertheless, the feasibility of activities was

guaranteed through a permanent contact and interaction that allowed for the maintenance of routines and proximity between peers at a time in which face-to-face labor relations were compromised. Learning in (and in this) context, met the needs of educational institutions and the needs of operational assistants, and the process of self-assessment/continuous discussion in each activity made it possible, through moments of reflection, to correct and guide behaviors and attitudes as close as possible to the events, which facilitated and streamlined the assimilation of new behaviors. In addition, from the evaluation of the project «The School Grows with Us» emerges the notion, almost unanimously, that the training-capacitation action fulfilled the objectives outlined that guided the intervention project and changed the lives of the operational assistants who work in it and that participated, whose positive effects, measured in the short term, are expected to last. In short, in this training action, the institutional, labor and individual dimension were contemplated, in which the contents were transmitted and learned in a way considered correct by the educational agents involved, and at the right time, taking into account the intervention needs and the challenges that schools face daily.

5.2. Evaluation of the Results for Future Training-Capacitation Actions in Context

The evaluation process of this educational project is marked by a methodological design that intentionally aimed to combine several techniques and instruments of collecting and analyzing data, allowing us to consider and reflect in depth about multiple dimensions of analytical interest, and that eventually would not be addressed in a smaller evaluation. A multi-method analysis revealed aspects that go beyond institutional weaknesses and needs, by also incorporating the subjective dimension. Listening to the perceptions and perspectives of directors and operational assistants face to face and confronting the perspectives made it possible to identify the causes and consequences of these same weaknesses and needs, tracing guidelines of action for the future.

When developing (future) training activities in context, educational institutions and their training entities must consider that:

(a) Learning must also be perceived as necessary and must create an impact on the beneficiaries. In this specific case, the targeted audience has, in the first place, to perceive that the fruit of their participation in the training action benefits them, directly and indirectly. Directly given the enhancement of their performance and the increase in their levels of autonomy (despite the absence of external rewards, such as salary increases), and indirectly as the institution, by benefiting from a more optimized performance of its employees, can recognize their abilities, assigning functions that best suit them.

(b) The learning process becomes more effective when the recipients are involved in a process that generates change and allows the identification of concrete transformations. The content is more easily assimilated if there is a feeling of involvement.

(c) The contents and technical knowledge are more easily learned when articulated with the practical component at the same time. The relationship between knowledge and action is reinforced since the behavioral correction is immediate and in loco.

(d) If the sensation of evaluation by third parties is put in second place, performance levels are optimized. The learning process should remove the feeling of fear caused by the assessment, mostly if there is a perception of vulnerability of keeping the professional positions already held. Training in a real work context by encouraging a critical spirit and self-correction streamlines the learning process and consequently increases the receptivity to learn and assimilate new behaviors and contents without pressure.

Planning an intervention in an educational context when oriented towards specific professional groups implies the necessity to assume that it should not be guided by bureaucratic needs, which generally resort to highly standardized operating mechanisms, which disregards the framework, characteristics and effective needs of people and the institutions in which it is intended to intervene. Moreover, it should be taken into account that the developments produced have repercussions in

peoples' lives and institutions [27]. In the case of Sintra, the malleability of the interventional plan, meaning a plan that introduced the necessary flexibility to adequately make a change, not limited to the implementation of a sequential set of strategies dispersed according to the political-educational objectives to be achieved, demonstrated that paying attention to the diversity of contexts allows one to reduce obstacles and the resistance to development.

This provides not only the construction of local systems able to respond to different educational needs of territories, but also allows one to design a set of strategies of intervention that consider and involve the educative community in general.

6. Discussion

It is important to reflect about the role of operational assistants as agents who establish close connections with students and are present throughout their school path, as this connection ends up being more pronounced than the one expected with the professors given their rotation over the years. Thus, assistants spend much more time, for more years, in contact with each student. Our results confirm the relevance of operational assistants in the school context as they are more present in the various social spaces of the school, where there are countless, differentiated and significant interactions with and between students, to which professors do not have access very often. Given that, in the Portuguese tradition, the responsibility for these spaces does not rest with the professors, limiting their responsibility essentially to the classroom, but since it is a responsibility that is assumed by the educational institution, it is essential that the operational assistants are able to upgrade their duties and their real mission at school.

It should be noted that it is not enough to train, but also to formally recognize this training by considering the ambitions of these professionals. Thus, regarding the valuation and career development of operational assistants, they are constantly required to improve their skills and competencies, which do not correspond to their level of remuneration and professional progression.

Another relevant aspect concerns the increasing importance that municipalities assume in the construction, implementation and evaluation of local educational policies. Municipalities should use their political power to intervene in various areas, such as the one of education, potentializing the resources they have access to. In this sense, it is important to highlight the importance of funds for local development such as the one applied to the project "The School Grows with Us" by the Sintra municipality.

The training and capacitation actions, although important, can only be realized if supported by a financing system that allows it. We highlight the Sintra municipality for having the needed financial means (in conjunction with funds from the European Union), which makes it an example of what should be expected from an effective management of the right to education and that combats school failure.

Thus, the understanding that the operational assistant can also be an agent that operated for change on the educational context was underlined since the conception of the global intervention project—an aspect that was revealed to be beneficial, recognizing the capacitation of the operational assistants as a motor for the improvement of their professional development as well as the institutional development of the schools of the municipality of Sintra.

The evaluation of the impacts of the project came to confirm its adequacy and the benefits of learning in a real work context. Articulating practical exercises with the new acquired skills demonstrated an appropriate tool to capacitate with efficacy this professional group, responding to the specific problems that needed intervention.

Aside from increasing the levels of performance and efficiency, sustained by the significant increase in technical and professional knowledge (about subjects poorly consolidated or that were completely strange), the training action in the work context contemplated socialization processes, integration and participation in which the learning process was not only focused on the organizational

context but were enlarged to the different plans of social life of the operational assistants, namely their self-valorization.

It is understood that the training activities in the work context acted on the (re)creation of conducts and fostered the sharing of perspectives and experiences and consequently promoted a substantial development of socio-behavioral skills—which was also of great importance at the level of labor relationships, productivity and well-being, were not work one of the essential places of identity construction, integration and socialization [40–42].

Furthermore, considering that, in the school context, operational assistants do not perform functions in isolation, the training actions should not only contemplate the specific contents related to improving the performance of these professionals, but also consider the relationships that this performance establishes with other functions within school and, in particular, between operational assistants and professors. Since performance does not depend solely on the worker, training in real work context empowers not only those who were targeted, but also other groups in the same organization. In order for operational assistants to enhance their performance, it is necessary that both the teaching team and the management staff are aware of their skills, knowledge, experience, and who values and accepts them, incorporating their (new) contributions in the routine of the school organization. Translating into an opportunity to act on the collective understanding that life at school implies the real involvement of all, training-capacitation actions in schools should be an investment that takes into account the integrated objectives of organizations and not only directed to specific professional groups that may compartmentalize the performance of school agents even more.

It should be noted that the evaluation concentrated on itself a double application. This means that it not only allowed for elucidating the most appropriate strategies to implement, in function of the intended change, but also acted as a driving tool of the learning context, by enabling agents to confront, through the mobilized methodologies, with the advantages, disadvantages and potentialities of the training-capacitation actions. It is in this process of confrontation with reality that one seeks to change, that the primary function of evaluation serves its useful purpose, (self) correcting and coherently guiding the strategies and actions that must be carried out, improving the internal management of the project and the adequate use of means and resources to achieve the desired objectives. The evaluation process is itself a learning process. An assessment that integrates a component of collaborative reflection, promotes the production of transformative individual and organizational learning [43]. An assessment that does not generate learning, for all stakeholders, is not an assessment that promotes any change.

Moreover, it should be noted that the implementation of training actions is often perceived as a bureaucratic obligation, which is subjected to mere and superficial inquiries of the recipients' assessments. It is understood that one of the reasons for this to happen is due to the fact that those responsible are not familiar with the principles and procedural logic of evaluation [44]. At this level, it is imperative to alert to the understanding of how important it is to continually train and qualify these professionals for the performance of a profession that is under several transformations. It is also reinforced that the evaluation has a fundamental role, since, in this context, the reassessment of needs allows us to engage at the level of personal and technical-professional development, by acting on the maintenance of the practices and the consolidation of the acquired skills and learning, thus guaranteeing the sustainability of the demonstrated results. In short, training and capacitation actions, whatever the professional group targeting, only achieves sustainable and lasting results when undertaken under a broad and robust evaluation program, based on the very context in which the professional activity is developed.

7. Conclusions

Schools now more than ever recognize that operational assistants are an important element in its context. However, even with an understanding of the important role that the operational assistant has in the construction of an educational environment of quality, very rarely is this professional perceived

as an educational agent. Therefore, we face the need for a reconfiguration process of the functions these professionals perform, that is, a switch from their auxiliary and instrumental duties to more intrinsically educational ones.

The different professionals that integrate the school context cannot limit themselves to their specific functions but should be flexible and have the ability to adapt and articulate with other professionals in the organization. We refer, mainly, to a stricter relationship and cooperative between professors and operational assistants, reducing therefore the asymmetries present in the hierarchal relations between these professionals. The existence of closer relations translates into more directed and adjusted ways of action and intervention by both professional classes, which, based on the sharing knowledge and experiences, implicitly leads to a reciprocal appreciation and with it a good educational environment promoter of equity.

It is important to affirm that the institutions that analyze and evaluate this type of project, namely universities, should maintain a proximity to the promoting entities of these projects. It is fundamental that a constant review and evaluation of the quality of the educational politics exists, allowing for the observation/follow up of the measures applied [45]. This way, we believe that the feedback given to the promoting institution of this project, the municipality of Sintra, is the most relevant aspect together with the impacts of the training-capacitation action near the operational assistants. Without evaluation, it is not possible to understand the reality before and after the development of a project, fundamental to the consolidation of solid and effective public policies. The appreciation of the evaluation of public policies, from the intervention programs to the local level, is not reduced to a mere statistical measurement of the most immediate effectiveness of actions. It is necessary to determine the different plans and domains of the impacts of the training-capacitation action, and its potential to produce an effective change, not only in the working sphere, but in the life of these professionals, and the effects produced by it; these changes were immediately recognized by the operational assistances and the school's boards.

The evaluation of educational projects and policies has, in previous years, proved to be one of the concerns of central and local governments. Considering the growing complexity that follows the creation of public policies in the most varied fields and its process of implementation and evaluation, it is worth mentioning the integration of specialized professionals, which are aware of the (complex) social reality and its social and political problems [46], in order to use theory as a reference and tool to evaluate and measure the validity and the reach of conclusions built in the evaluation process. This dynamic is not only indicative of a greater visibility and importance given the expert knowledge which contributes to increase the participation and intervention, but also of a greater recognition of science, of its role and value. This way university institutions see that their role has a higher importance to research, analyze, evaluate, produce, and disseminate new knowledge.

The role of higher educational institutions in evaluating educational policies, whether of local, regional and/or national focus, should be reinforced, which will bring mutual benefits for the institutions and the agents involved. The contemporary educational challenges are still diverse and demand better tools for the evaluation of the processes and impacts. The use of an integrated perspective of the learning context has revealed to be pertinent, consolidating scientifically the evaluation of public educational policies.

The team of researchers responsible for the evaluation of the educational public policy implemented in Sintra concluded that it contains major potential to change the school system, not only with regards to a set of communication and information skills but also to develop new technical and professional, personal and interpersonal skills acquired by the operational assistants. They started to occupy a new recognized importance, being given more value in the relationships with the rest of the educational agents, namely the school boards, teachers, students and their families. The recognition of operational assistants, which occurred thanks to the investment that the municipality of Sintra attributed to them when they decided to implement the project «The School Grows with Us», produced impacts in schools that goes beyond the operational assistants, specifically in the way school boards expanded their horizons regarding the competences that these professionals can perform in the school. This valorization

of the operational assistants, shared by an increasing number of educational agents, powered by a significant number of school groupings, increased qualitatively the human resources of the schools of Sintra, which may mean, in the short-to-medium term, a visible improvement in the academic success of the students residing in this Portuguese municipality.

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Student-Centered and ICT-Enabled Learning Models in Veterinarian Programs: What Changed with COVID-19?

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Abstract: COVID-19 highlighted higher education's resistance to implementing the student-centered and ICT (information and communication technology)-enabled learning practices as incentivized by the Bologna Declaration. ICTs were crucial to keep the students in educational programs during the outbreak; however, some students were left out, increasing socioeconomic differences, and many teachers needed the training to provide online lectures effectively. Despite those barriers, the current context could be an opportunity to invest in new teaching and learning practices. The main goal of this research is to analyze how teachers and students from veterinary programs in Portugal adapted to the digital environment, and perceive whether this change imposed by COVID-19 could provide teachers and higher institutions with new solutions to implement effective student-centered and ICT-enabled learning models. Results show that veterinary programs are based on student-centered practices by nature, but that the use of ICTs is still incipient. Teachers, students, and members from the Professional Order claim that the worst change brought by COVID-19 was the cancellation of hands-on sessions, impoverishing the students' education during the time of mandatory confinement. Actors say that it is important to invest in innovative teaching and learning practices enabled by ICTs in the future.

Keywords: learning models; use of ICTs; higher education; veterinarian education; COVID-19

1. Introduction

Educational innovation is a top priority worldwide because it is considered pivotal to promoting competitive and inclusive economies [1]. Within that context, information and communication technologies (ICTs) could have a key role as possible enablers of innovation in education and training. Innovative educational projects appear to be increasing in several countries [2]; however, some studies [3] show that education systems are not applying ICTs to their full potential. In higher education, pedagogical innovation and the use of digital resources are still "in the early stages of development" [4] (p. 1054); and some teachers are still reluctant or at least unenthusiastic about using ICTs [5].

This scenario also applies to Portugal. Several studies reveal that many teachers still use traditional learning models in most national higher education programs because classes are based on expositive and curriculum-centered pedagogical practices and students assume little responsibility for their own learning process and tend to mobilize memorization techniques during evaluations [6,7]. This has slowly been changing since the Bologna Declaration, but researchers found that learning methods are still far from student-centered education in our country because many teachers and students are still not prepared for these new pedagogical practices [2].

The burst of the COVID-19 pandemic last March brought this reality back to light when governments, teachers, students, and families were pushed to quickly learn how to mobilize technologies to engage in online lectures, enhancing deficits in accessing and using ICTs. From primary to higher education, everyday classes were very quickly adapted to the digital world. But we now know that some students were left out of digital school, consequently increasing socioeconomic differences, and that some teachers struggled to use ICTs proficiently in order to successfully conduct their classes online; that means that for many teachers and students this "new" online school was not a good experience [8].

In higher education, programs usually include practical classes, and for some areas of expertise, those hands-on moments are crucial to training students to face real-life problems in the future. All medicine programs, for example, put their students through intense hours of hands-on sessions such as, for example, rotations in hospitals, internships, etc. [9]. Veterinary programs also provide hands-on sessions on and off campus. This added difficulties in creating credible solutions because higher institutions lack the technologies that could help teachers provide effective hands-on sessions with simulators (similar to what is used to train pilots, for instance), 3D images, and so on, many of which are already used in some human medicine programs. The main goal of this brief study is to analyze the role ICTs played in learning models before and after COVID-19: How did teachers and students adapt? What were the outcomes of online lectures in veterinarian programs? Could we expect learning models in these programs to increase the use of digital resources such as, for example, mobile applications to learn about animals' anatomy and how to proceed in medical interventions in the future?

ICTs are sets of technological resources used to gather, distribute, and share information that facilitates automation and communication, whether in business, research, or education. The rapid advances in technology are changing the way education is planned and implemented and the way children learn, communicate, and socialize all around the world [10]. This justifies the increasing interest of national governments, international organizations, researchers, and schools in applying digital technologies to improve learning and teaching. By using ICTs, teachers can provide students with opportunities to actively engage in learning and to build knowledge. Technologies enable flexible teaching methodologies that could help to reach disadvantaged groups and also enable the processes of engaging and challenging students with subject matters as real-life problems, of stimulating communication and discussions about the subject matters, and of "learning by exploring, experiencing, discovering, constructing, reflecting and acting" [11] (p. 105).

As such, ICTs can play an important role in the process of transforming education by enabling it but are not the key solution. The use of ICTs brings many challenges to teachers because it highlights the need to reorient towards building more constructivist learning environments and also the need to learn how to use new technologies that are already being used by students with proficiency. Teachers are confronted with the necessity of changing how they prepare and dynamize classes towards using teaching methods that give the students an active role to learn, investigate, reflect, etc. [11]. That is why, according to Moran et al. [12], teachers cannot be replaced by ICTs, even though technologies have surely changed their job description because the information is now available everywhere (in books, the internet, videos, streaming services, and so on). They continue to have an important role, but now as mediators of the students' learning process by creating problems and asking questions, guiding the students during research, and inciting reflection and debates about the subjects [13], or by applying student-centered learning models as opposed to traditional ones.

Student-centered learning is nowadays proclaimed by scientific literature and politics as the most suitable method of teaching and learning to transition to a paradigm of knowledge construction from knowledge transmission [14]. To achieve this, classes must be planned to implement student-driven learning activities, balancing theory (literacy, numeracy, sciences, etc.) and practice (experimenting, researching, discussing, talking about how students perceive the world, etc.), both contextualized in students' daily life, customs, and culture. The implementation of student-centered learning processes

is the way to contribute to students' learning to know, to be, to live together, to do [15], to transform oneself and society [16], and to give and share [14].

However, learning models in higher education still tend to be traditional, or teacher/curriculum centered [3,12,17], which leaves little room for alternative approaches to both teaching and learning [14]. ICTs are mainly used as administrative tools (for managing registrations, payments, grades) or as a communication tool between each student and each teacher. Hence, ICTs are not yet fully embedded in formal education practices [3] and have not been enough to transform education [4]. For Gesser [18], a stiff curriculum structure, teachers' resistance to change and lack of practice using ICTs, students' low capacity to stay focused, and the lack of financial support from higher institutions are some of the factors that could help explain the resistance to innovate teaching and learning practices enabled by ICTs. Moran [19] claims that higher education institutions are conservative and guided by traditional cultures that resist change, hence their lingering in traditional learning models. Unlike Gesser [18], this author says teachers know their pedagogical practices must change but do not know how, so they resist while simultaneously making smaller concessions, for example, by using universities' platforms to communicate with and grade students (Moodle platform in Portugal). Moran [19] enhances the fact that aside from training in the use of ICTs, teachers also need training to implement ICT-enabled pedagogical practices and student-centered learning models. And, he adds, some institutions enhance the teachers' resistance by demanding changes without providing the necessary support.

Changes are slowly happening, even though current educational reforms tend to focus on setting standards and assessment procedures instead of pursuing true innovation in education [20], defined as the implementation of student-centered learning experiences where students may use creativity and collaborative learning to find solutions for the problems given to them, and teachers are facilitators of learning and not mere distributors of information [19,20].

Following Ellison's perspective [21], we distinguish between ICT-enabled educational innovation in two different categories: administrative when focused on the institution's organization and administration processes, and instructional, which occurs when learning models (pedagogical practices, achievement assessment, and curriculum approaches) change by using ICTs. To provide students with rich learning environments, boost their motivation to learn, increase academic achievement, and prepare them for the 21st century, it is fundamental to mobilize ICTs in learning processes [22] as new ways to use and create information and knowledge and not just to replicate traditional learning practices [23]. Technologies can be instrumental to approaching the curriculum in a more interesting way, for example, by creating the possibility to bring real-life problems into the classroom, to provide tools to enhance learning, to review and test knowledge more often, to give faster feedback to students about their performance, to incentivize reflection and debates on their ideas, and also to create global communities among all students, teachers, and outsiders, thus expanding the learning experiences [24].

However, it all depends on how teachers mobilize technology in the classroom [5,18,19]. While some use ICTs to teach the standard curriculum through traditional learning models [25], others are using ICTs within a constructivist approach that see students as active agents (setting the goals and planning and monitoring their learning process), working collaboratively with their peers and engaging to find solutions to real or real-based problems by mobilizing different disciplines [24]. This author found evidence that teachers are increasing use of student-centered learning models with ICT-enabled pedagogical practices. Nevertheless, implementation of ICT-enabled learning models, such as e-learning, m-learning, digital models, or artificial intelligence and simulators, is still challenging in higher education because of social, cultural, organizational, [4] and, we might add, funding variables.

Many authors created models and classifications for ICT-enabled innovation for learning. Among the most interesting are the three degrees of innovation of the Organization for Economic Cooperation and Development (OECD) [26]: (i) incremental, as in minor changes in services/products; (ii) radical, when it introduces new services or new practices related to services/products; (iii) or systemic, when new dimensions are introduced in the overall performance. Law et al. [27] developed six dimensions

of analysis following an ecological study about emergent ICT-enabled pedagogical innovations: (i) learning objectives, to analyze which curriculum goals align with 21st-century skills; (ii) teachers and (iii) students' role in differentiating between emerging and traditional pedagogical practices; (iv) level to which ICTs are used; (v) connectedness, or level of involvement of outsiders (experts and parents, for example) in teaching and learning processes; and (vi) a multiplicity of learning outcomes. Each dimension is then evaluated within the scale of innovativeness between the levels of traditional (traditional in all six dimensions, or teacher-centered, where ICTs are used to replicate traditional learning models), emergent (midway), and most innovative classrooms (innovative practices in all six dimensions, or student-centered).

Our model of analysis (Figure 1) was created from the theories and discoveries by Moran [19], Fullan [20], Ellison [21], and Law et al. [27] to identify the learning methods and the role technologies play in pedagogical practices before and after COVID-19 in Portuguese veterinarian programs, how teachers and students adapted to changes, what the outcomes were, and what is to be expected in the future.

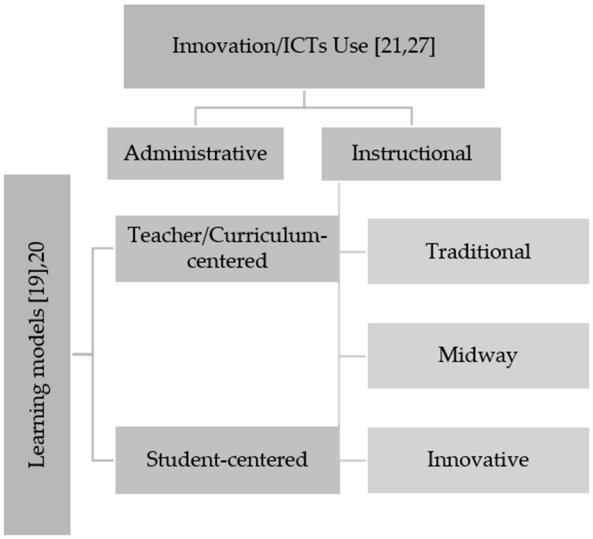

Figure 1. Scheme of the model of analysis.

Learning models can be teacher/curriculum centered when characterized by expositive and inquisitive pedagogical practices, an active role from teachers who transmit information and evaluate the students about the amount of information learned and passive roles from students; or student-centered when teachers assume the role of mediators of the students' learning process and students take responsibility for setting their own objectives, study methods, and results [19,20]. Innovation in education through ICTs can be administrative when used as a tool to help the institution and class organization or instructional when teachers mobilize ICTs in their pedagogical practices [21]. The use of ICTs in pedagogical practices then divides into (i) traditional when teachers only use technologies to replicate teacher-/curriculum-centered learning models, (ii) midway when some dimensions show signs of innovativeness; (iii) or innovative when objectives, students' and teachers' roles, use of ICTs, the involvement of outsiders, and the outcomes are defined as part of the student-centered learning models [27].

2. Materials and Methods

This research about the learning models and the use of ICTs in veterinary programs in Portugal was possible because a team of researchers from Centre for Research and Studies in Sociology of the University Institute of Lisbon (CIES – Iscte-IUL) started a study about the profession of the veterinarian in the national context in July 2019 with three main objectives: (i) Make a complete diagnostic about

the profession of the veterinarian in Portugal (formal education and training, access to the professional activities, employment, representation, the effects of the COVID-19 pandemic on formal education and professional activities, and professionals' representations about the previous dimensions), (ii) build a "veterinarian census" to characterize the population of veterinarians working in the national territory in all dimensions, and (iii) provide recommendations for the elaboration of a strategic plan for the Professional Order. For this article, we focused on the data collected from interviews applied to teachers and students of the Portuguese higher education institutions with veterinarian courses.

There are currently seven veterinary programs in the national context: four in public higher education institutions and three in private institutions. Two of the private options were not included in the study. One opened in 2020 after the conclusion of fieldwork (July 2020). The other never answered the invitations to participate in the study despite several efforts and attempts made by the team of researchers and the members of the Professional Order of Veterinarians. Therefore, this study only includes five veterinary programs from four public institutions and one private institution. The oldest opened in 1830 in Lisbon, in an institution that is nowadays known as the Faculty of Veterinarian Medicine of the University of Lisbon (UL); this is currently the institution that graduates the most veterinarians every year. The other public programs started in 1975 in Évora (in the south) in the Escola de Ciências e Tecnologias from the University of Évora (UE), in 1987 in Vila Real (in the north) in the School of Agrarian and Veterinary Sciences from the University of Trás-os-Montes e Alto Douro (UTAD), and in 1994 in Porto (also in the north) with the creation of the Institute of Biomedical Sciences Abel Salazar from the University of Porto (UP), which is characterized by developing work within the paradigm of One Health. All these are public institutions that changed their statute, structure, and organization throughout the years but kept their veterinary programs active from before the aforementioned years. The programs in the private institutions opened much later. The first and only one that was included in this study opened in 1998 in Coimbra (in the center of Portugal) in the School University Vasco da Gama (SUVG). A second program began in the same year in the Universidade Lusófona de Humanidades e Tecnologias in Lisbon and a third opened in CESPU—Cooperativa de Ensino Superior Politécnico e Universitário—in Porto (these are the two programs not included in the study for the reasons explained above). From this point on, we will use the acronyms to designate the programs/institutions to facilitate the writing and reading processes.

The study was conducted in five higher education institutions (UL, UE, UP, UTAD, and SUVG), in the Academic Federation of Veterinary Medicine (which represents students enrolled in all veterinary programs in Portugal) and the Professional Order of Veterinarians. Data was collected through interviews and documents.

First, we applied 20 interviews: (i) individual interviews with three teachers and the director from the five veterinary programs indicated above; (ii) group interviews, one with the four leaders of the Academic Federation of Veterinary Medicine, and one with six members from the Professional Order of Veterinarians (scheduled to discuss specifically the impact of COVID-19 on formal education, training, and the profession itself). With the exception of the interview that focused on the impact of COVID-19, all interviews followed a script built by the CIES—ISCTE-IUL team in the context of the study about the veterinarian profession in Portugal and were applied by three members of that same team. The script included several questions organized in four different dimensions: (i) formal education and training, (ii) access to professional activities, (iii) employment, and (iv) representations of the profession. Data was collected by applying semi-structured individual and group interviews to ask about the previous specific dimensions and provide a certain level of normality to allow for the comparison between actors and institutions [28] and, simultaneously, guarantee the interviewees the time to reflect on the subjects and answer the questions freely [29].

For the present article we only used interviewee responses about formal education and training, more specifically about the curricular plans, classes, teaching and learning methodologies, how they organize programs (student enrollment, tuition payment, evaluation process), and the impacts of COVID-19 when available.

Some interviews were conducted face-to-face before the COVID-19 outbreak and do not have data about the changes the pandemic introduced. This is the case with the interviews from the director and two teachers from UL, and all four interviews from UE and SUVG (Table 1).

Table 1. List of interviews, type, and application.

Institutions	Actors	Type	Application
University of Lisbon	Director 1	Individual	In person
	Teacher A	Individual	In person
	Teacher B	Individual	In person
	Teacher C	Individual	Online
University of Évora	Director 2	Individual	In person
	Teacher E	Individual	In person
	Teacher F	Individual	In person
	Teacher G	Individual	In person
University of Porto	Director 3	Individual	Online
	Teacher H	Individual	Online
	Teacher I	Individual	Online
	Teacher J	Individual	Online
University of Trás-os-Montes e Alto Douro	Director 4	Individual	Online
	Teacher L	Individual	Online
	Teacher M	Individual	Online
	Teacher N	Individual	Online
School University Vasco da Gama	Director 5	Individual	In person
	Teacher O	Individual	In person
	Teacher P	Individual	In person
	Teacher Q	Individual	In person
Academic Federation of Veterinarian Medicine	Student 1	Group	Online
	Student 2		
	Student 3		
Professional Order of Veterinarians	Several members	Group	Online

As indicated previously, we also collected data from specific documents: (i) the evaluation reports from the Portuguese agency that accredited the six higher education programs in Portugal, including ULHT, to provide an analysis of the curricular plans of each veterinary program; (ii) and the Evaluation Report of Curricular Plans of six veterinary programs written by the Academic Federation of Veterinarian Medicine in the year 2018–2019 based on the results from a questionnaire applied to a total of 1214 students (corresponding to 45% of the total of 2689 students enrolled in veterinary programs) to collect data about the perceptions of the students on the six veterinary programs (ULHT included as well). These reports were used as qualitative sources of information in this study to complement the main results and were not subjected to the same coding and categorization process as the discourses collected through interviews.

2.1. The Coding and Categorization Processes of Interviewees' Speeches

Considering this set of data, we used a qualitative approach to study the learning models and the use of ICTs in veterinary programs.

Content analysis was used as an adequate qualitative technique to analyze all speeches produced by the interviewees. This process was organized according to the dimensions drawn from the questions presented at the beginning of the article and the model of analysis presented in the previous section: (i) learning models of veterinary programs, (ii) use of ICTs, (iii) changes caused by the pandemic outbreak, and (iv) teachers and students' perceptions about the changes and future outcomes. In the first dimension, learning models, we searched for references of teacher-/curriculum-centered and of student-centered practices. Then we analyzed how institutions and teachers use ICTs to identify if the use is just administrative or if there is an instructional use of ICTs and what kind (traditional, midway, or innovative). In the third dimension we identified all changes that were indicated by the actors, and their discourses point to two different categories: changes in lectures and changes in hands-on sessions. In the last dimension we listed the actors' perceptions about the changes and outcomes for the future regarding students' education, curricular plans, and teaching and learning practices.

Throughout this process we used one analytical grid to efficiently operationalize the comparison between programs/institutions and actors (the analytical grid was summarized in the tables presented in the Results section).

2.2. COVID-19 in Portugal

The COVID-19 pandemic and the perceived impact of the confinement measures on education motivated us to write this article. Not only was the process of collecting data within the project about the veterinarian profession in Portugal affected (rescheduling interviews, adapting the scripts and researchers instructions to a digital environment, etc.), but the interviewees' speeches also started to include reflections about the significant changes in teaching and learning brought on by the mandatory confinement. Throughout that project, professionals, teachers, and students stated that veterinary programs are very dynamic and intense because of hands-on sessions, which is the opposite of what students usually say about their higher education programs. Therefore, we wanted to know more about the veterinary programs' curricular plans and teaching and learning practices, and about the changes imposed by the pandemic outbreak.

The pandemic started officially in Portugal on 2 March, 2020, the day when the first two positive cases were confirmed on national territory. The government responded with several containment measures, such as canceling sports and cultural events and locations, for example, while asking the population to remain home and take the necessary precautions. But due to the exponential increase of COVID-19-positive cases, the government declared a State of Emergency on 18 March, 2020, and with it mandatory confinement and the lockup of all public and private organizations and businesses. However, the Portuguese population, organizations, and businesses started to implement their own measures before the declaration of the State of Emergency. Higher education institutions, for example, implemented contingency plans that were adjusted regularly and eventually canceled all on-campus classes and national and international field trips. Iscte contingency plan started on 10 March, 2020, three days before the trip to Vila Real to apply the interviews in UTAD that had to be rescheduled to June. From mid-March through the end of the school year, the entire Portuguese education system transitioned to digital lectures.

3. Results

Before presenting the results, it is important to show that the curricular plans of the six Portuguese veterinary programs are very similar because all institutions follow the guidelines from the European Association of Establishments for Veterinary Education (EAEVE) created in 1988 with the following mission: "to evaluate, promote and further develop the quality and standard of veterinary medical establishments and their teaching within, but not limited to, the member states of the European Union" [30]. In order to be accredited, each institution must prove that the veterinary program answers the standards defined by EAEVE for several different items organized in 10 dimensions: (i) objectives, organization, and quality and assessment policy; (ii) finances; (iii) curriculum; (iv) facilities and

equipment; (v) animal resources and teaching material of animal origin; (vi) learning resources; (vii) student admission, progression, and welfare; (viii) student assessment; (ix) academic and support staff; and (x) research programs and continuing and postgraduate education. Focusing on the "curricular" dimension, all programs must be integrated masters (with a minimum of 360 ECTS (European Credit Transfer and Accumulation System) credits) and have a curricular plan based on lectures and seminars about (i) basic subjects (such as chemistry and biology, for example), (ii) specific veterinary subjects (basic sciences, clinical sciences, animal production, food safety and quality, public health, and One Health Concept), and (iii) practice sessions such as supervised self-learning, laboratory and desk-based work, non-clinical animal work, clinical animal work, and an internship (all of which we address in this paper as hands-on sessions, as designated by teachers and students).

The curricular plans of the six veterinary programs are very similar (see Table 2) and built from information collected from the six institutions' websites [31]; however, in the national context, UL has the only accredited program by the EAEVE, and the one from UTAD has been approved and is still in the process of accreditation. Among other reasons, directors and teachers from UL and UTAD claim that the diversity of facilities and equipment, multiple animal resources and teaching material of animal origin, and diverse learning resources are a major part of their institutions' accreditation and approval.

Table 2. Number of curricular units (CU) and European Credit Transfer and Accumulation System (ECTS) credits for each veterinary program.

Veterinary Programs	General Basic Subjects	Specific Veterinary Subjects (SVS)				Hands-On Sessions	
		Basic	Clinical	Animal Production	Food Quality and Safety	Practice Sessions	Internships
University of Lisbon	1 CU/ 4.5 ECTS	14 CU/ 65 ECTS	31 CU/ 141 ECTS	6 CU/ 26.5 ECTS	1 CU/ 4.5 ECTS	10 CU/ 10 ECTS	1 CU/ 30 ECTS
University of Évora	2 CU/ 11 ECTS	15 CU/ 78 ECTS	33 CU/ 143 ECTS	8 CU/ 36 ECTS	3 CU/ 14 ECTS	7 CU/ 11 ECTS	2 CU/ 60 ECTS
University of Porto	2 CU/ 11 ECTS	14 CU/ 64 ECTS	27 CU/ 162.5 ECTS	8 CU/ 32.5 ECTS	5 CU/ 23.5 ECTS	Included in SVS	1 CU/ 30 ECTS
University of Trás-os-Montes e Alto Douro	2 CU/ 6 ECTS	11 CU/ 61.5 ECTS	37 CU/ 160 ECTS	6 CU/ 26 ECTS	2 CU/ 12 ECTS	Included in SVS	5 CU/ 11 ECTS
School University Vasco da Gama	2 CU/ 7.5 ECTS	16 CU/ 85.5 ECTS	36 CU/ 151 ECTS	7 CU/ 23 ECTS	4 CU/ 18 ECTS	4 CU/ 20 ECTS	1 CU/ 30 ECTS
University Lusófona of Humanities and Technologies	4 CU/ 15 ECTS	15 CU/ 68 ECTS	31 CU/ 120.5 ECTS	6 CU/ 25 ECTS	5 CU/ 23 ECTS	12 CU/ 26 ECTS	1 CU/ 30 ECTS

But all the other three interviewed directors (from UE, UP, and SUVG) stated they would also like to have their programs accredited, and that is why all curricular plans are very similar (CU and ECTS values are alike).

There are minor differences between the six veterinary programs concerning the focus that some areas of veterinarian medicine receive (for example, food security is more relevant in SUVG and animal production in UE) or the number of ECTS (European Credit Transfer and Accumulation System) credits assigned to practice sessions and internships. The CU and ECTS numbers in Table 2 clearly show that all curricular plans focus the area of the clinic (whether small or big animals) and include a considerable amount of ECTS credits for hands-on sessions, as requested by EAEVE guidelines. This is because veterinarian medicine, especially in the area of the clinic, is developing fast in terms of animals' diagnosis and treatment as a response to societal changes such as the process of animal humanization, which implies higher demands from and expectations for veterinarians and a higher number of students looking forward to getting an education in that specific area. The members of the Professional Order of Veterinarians show signs of concern about what they say is the excessive number of veterinary programs in Portugal, especially compared to other European countries and considering that only two of the programs were accredited/approved by EAVE, raising doubts about the quality of the other programs.

3.1. Learning Models in Veterinary Programs

According to the five directors and 15 teachers that were interviewed, their aim is to train new autonomous veterinarians capable of handling different types of animals, making the correct diagnosis and setting the right treatments, and, simultaneously, make professionals aware that they need to keep updated with all the new developments of the diverse areas of veterinarian medicine. The perceptions from the members of the Professional Order of Veterinarians and the leaders of the Academic Federation about what future veterinarians must be are consistent with the profile defined by the directors and teachers.

To achieve those objectives, teachers gave examples of pedagogical practices (see Table 3) such as using real-life cases for students to diagnose and define treatments or train intervention techniques (Teachers A, B, C, M, O, P, Q), taking field trips to train with different areas and animals (Director 1, Teachers E, H, I, J, M, N, O, P, Q), and service in hospitals and other facilities on and off campus (Teachers B, F, L, M, P, O, P, Q). Some teachers also consider it important to train the students in soft skills such as, hospital and/or clinic management (Teacher L), communication tools for talking to clients (Teachers B, L), ethical issues (Teachers E), searching and validating information (Teacher F), and thinking about veterinarian medicine as a multidisciplinary area that is constantly developing (Director 3, Teachers C, H, O).

Table 3. Teacher-/curriculum-centered and student-centered practices.

Institutions	Learning Practices	
	Teacher-/Curriculum-Centered	**Student-Centered**
UL	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Real-life problem solving (Teachers A, B, C) (ii) Field trips to train with different areas and animals (Director 1) (iii) Service in facilities on and off campus (Teacher B) (iv) Training in soft skills (Teachers B, C)
UE	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Field trips to train with different areas and animals (Teacher E) (ii) Service in facilities on and off campus (Teacher F) (iii) Training in soft skills (Teachers E, F)
UP	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Field trips to train with different areas and animals (Teachers H, I) (ii) Service in facilities on and off campus (Teacher L) (iii) Training in soft skills (Teacher H)
UTAD	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Real-life problem solving (Teacher M) (ii) Field trips to train with different areas and animals (Teachers J, M) (iii) Service in facilities on and off campus (iv) Training in soft skills (Teacher L)
SUVG	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Real-life problem solving (Teachers O, P, Q) (ii) Field trips to train with different areas and animals (Teachers O, P, Q) (iii) Service in facilities on and off campus (iv) Training in soft skills (Teacher O)
Academic Federation	(i) General use of traditional evaluation techniques (exams, oral exams) (ii) Transmission of knowledge in the first two years	(i) Huge amount of hands-on sessions on and off campus from the third year and through the end of the program

Hands-on sessions are considered important by all teachers because "it is necessary to teach students how to think and to keep up to date with constant developments in procedures, diagnosis, treatment, etc." (teacher A). All these examples are consistent with active roles from students and mediating roles from teachers who mix lectures with hands-on sessions and guide students in their learning processes. It is important to mention that some teachers claim they must fight students'

tendency to search for information and accepting "it as the truth without validating; they look, find, and use it and that is it" (teacher F), and to "memorize [because] that is the opposite of what a veterinarian must do. He/she must use different sets of knowledge to diagnose and treat animals" (teacher B).

However, we must also consider that in the first two years of veterinary programs, according to all interviewed teachers and students, curricular units focus on general basic and veterinary–specific basic subjects. The report about the curricular plans elaborated by the Academic Federation shows that students claim that some classes are too expositive, and the curriculum is not up to date with all developments in veterinarian medicine. The percentage of students that make this complaint is higher in the institutions where the average age of the faculty is higher, such as in UL, the oldest institution in the national territory. Interviewed students from the Academic Federation confirm that this is mainly a problem of the first and second years, saying that "in the last few years there has been more innovation and communication to students about new developments, unlike what happens in the first two years" (student 3). Teachers from the five institutions claim that in the first two years the programs tend to focus on general basic and veterinary-specific subjects because students must gather knowledge that they will have to use later during hands-on sessions and then as veterinarians. Teacher I, for example, says that veterinary programs emphasize "disciplines based on knowledge from the first years."

3.2. Use of ICTs

Beginning with the use of ICTs incentivized by the five higher education institutions, we observed that all of them have a platform organization to manage inscriptions, payments, and formal requests for documents or other requests from students, etc.; and to manage disciplines where teachers share documents, articles, books, and work requests; insert grades; and respond to students when they ask for guidance (see Table 4). As for learning models and ICT-enabled learning practices in the five institutions, there is no general policy and teachers have full autonomy to decide how to conduct their lectures and hands-on-sessions.

Table 4. Uses of ICTs.

Institutions	Use of ICTs			
	Administrative	Instructional		
		Traditional	Midway	Innovative
UL	(i) Moodle platform	(i) Visual aids (PowerPoint, Prezi, videos, etc.) (ii) Exams implemented through Moodle (Teacher C)	No evidence	No evidence
UE	(i) Moodle platform	(i) Visual aids (PowerPoint, Prezi, videos, etc.)	No evidence	No evidence
UP	(i) Moodle platform	(i) Visual aids (PowerPoint, Prezi, videos, etc.)	No evidence	No evidence
UTAD	(i) Moodle platform	(i) Visual aids (PowerPoint, Prezi, videos, etc.)	No evidence	No evidence
SUVG	(i) Moodle platform	(i) Visual aids (PowerPoint, Prezi, videos, etc.)	No evidence	No evidence

ICTS are usually used to replicate traditional learning models because teachers use computers and specific programs such as PowerPoint and Prezi as visual aids while conveying the information. The only other sign of ICTs being used as part of pedagogical practices came from Teacher C from UL. This teacher and several of her colleagues use the platform provided by the Portuguese government

for all public education institutions, the Moodle platform, to administer the exams (true-or-false question exams).

3.3. Changes Caused by COVID-19

UL was the only institution that had a version of the Moodle platform adapted for e-learning before the outbreak, and thus was fully prepared to transition to online lectures when the government decided to implement the mandatory confinement due to the COVID-19 outbreak. The other four only had versions to manage the program's organization and to serve as communication tools. Therefore they had to expand their Moodle platforms before they could begin distance education. All interviewed teachers and students said that all lectures were able to proceed with almost no changes, and all hands-on sessions such as service in hospitals and other facilities on campus, field trips, internships, etc., were canceled (see Table 5).

Table 5. Changes in lectures and hands-on sessions after COVID-19.

Institutions	Changes after COVID-19	
	Lectures	**Hands-On Sessions**
UL	(i) Proceeded online with minor adjustments	(i) Canceled all face-to-face hands-on sessions (ii) Somewhat replaced with images/videos from real-life cases (Teacher C) (iii) Impossible to replace surgical and clinical training with online lectures
UE	Not applied	Not applied
UP	(i) Proceeded online with minor adjustments	(i) Canceled all face-to-face hands-on sessions (ii) Impossible to replace surgical and clinical training with online lectures
UTAD	(i) Proceeded online with minor adjustments	(i) Canceled all face-to-face hands-on sessions (ii) Somewhat replaced with images/videos from real-life cases (Teacher M) (iii) Impossible to replace surgical and clinical training with online lectures
SUVG	Not applied	Not applied
Academic Federation	(i) Proceeded online with minor adjustments and saved time usually spent commuting to study (ii) Students felt more focused during online lectures	(i) Canceled all face-to-face hands-on sessions (ii) Some teachers made efforts to minimize the losses from hands-on session cancellation
Professional Order of Veterinarians	(i) Online lectures could be used as another instrument for study	(i) Impossible to replace surgical and clinical training with online lectures

In the curricular units, however, we found that some teachers were able to use ICTs in online lectures to maintain some moments that could be considered close to hands-on sessions. For example, Teachers C (imageology) and M (necropsies) provided images from real cases that students had to analyze, diagnose, and define treatment possibilities/determine the cause of death, thus training those skills. Teacher M stated that she and a colleague had no extra work transitioning their lectures to an online platform because they had been building a database of images, exam results, surgical procedures, and other items to be used as teaching and learning practice to train students to think, to make decisions, and to be autonomous.

However, most teachers say that it is more difficult to train students in clinical and surgical procedures at a distance. Even Teacher M, who was able to show her students all the steps to several surgical procedures through images that she had collected throughout the years, said that to "discuss real cases, how to talk to clients is one thing, but through online lectures, there is no way to substitute the training of students in the skill of using a real scalpel." Teacher L considers that teaching surgical skills online is "surreal" and added that she and her colleagues from UTAD are already working on a set of hands-on sessions to replace the ones that were canceled in order to allow students to train the necessary skills as soon as the institution reopens.

Teachers H, J, and L also consider that real-life interaction between teachers and students is crucial to showing the latter the right postures and maneuvers during technical procedures, how to behave near animals and clients, and to discuss with them the subjects, skills, and difficulties. They consider face-to-face interaction a crucial part of the students' training. All teachers consider that students' learning and training will not be complete unless they are given a chance to go back to real hands-on sessions with their teachers and with outside partners.

During the group interview with the leaders of the Academic Federation, we also asked students about the difficulties associated with attending online lectures. According to their own perceptions and those of the students they had asked about the access to online lectures, the leaders of the Academic Federation said they had had a few reports about a few students that could not attend education at a distance because they had no laptop and/or internet connection. However, this was not a problem for most students. Their perceptions about online lectures is that some teachers with whom they had hands-on sessions made huge efforts to minimize the losses from canceling practical classes and internships, but they feel it was not enough because they could not train the procedures with their own hands. Surprisingly, students claim that online lectures may continue in curricular units about general and veterinary-specific basic subjects because they had no distractions (no friends, no going to cafés, no conversations, etc.) and because it saved them time (no need to commute to campus and back home) that they used to study. This was also mentioned by the members of the Professional Order of Veterinarians, and one member added that online lectures that could be recorded and used as another instrument for study was a positive thing.

3.4. Teachers and Students' Perceptions about the Changes and Future Outcomes

Finally, let us look at the actors' concerns and hopes for the future following the changes imposed in veterinary education by COVID-19 (see Table 6).

Table 6. Perceptions about the changes to the students' education, curricular plans, and teaching and learning practices.

Institutions	Changes after COVID-19		
	Students' Education	**Curricular Plans**	**Teaching and Learning Practices**
UL	(i) Major losses from hands-on session cancellation	(i) A review was underway before the pandemic outbreak (Director 1, Teachers A, B, C)	(i) Continue e-learning in general/veterinary-specific basic curricular units (ii) Explore student-centered practices with digital files and computer-assisted learning (Teacher A)
UE	Not applied	Not applied	Not applied
UP	(i) Major losses from hands-on session cancellation	(i) Curricular plans must be reviewed regularly but not because of the pandemic outbreak (Teacher H)	(i) Continue e-learning in general/veterinary-specific basic curricular units
UTAD	(i) Major losses from hands-on session cancellation	No references	(i) Continue e-learning in general/veterinary-specific basic curricular units (ii) Explore student-centered practices with digital files and computer-assisted learning (Director 4)
SUVG	Not applied	Not applied	Not applied
Academic Federation	(i) Major losses from hands-on session cancellation (ii) Impossible to measure the real outcomes in the present	(i) Review and modernize the curriculum of general/veterinary-specific basic curricular units	(i) Continue e-learning in general/veterinary-specific basic curricular units
Professional Order of Veterinarians	(i) Major losses from hands-on session cancellation	No references	(i) Continue e-learning in general/veterinary-specific basic curricular units (ii) Opportunity to implement new teaching and learning practices

For teachers and students, the cancellation of all hands-on sessions represents major irreversible losses in the students' training and some defined it as a catastrophe (Teachers L, M, N) for students enrolled in their final year because they were not able to complete their internships. The common feeling among teachers can be summarized in the following reflection from Teacher H: "After this, I hope things change because of the needs of students and teachers and the developments within the various areas and disciplines and not because of the pandemic. The veterinary programs are dynamic and must be, and are, reviewed regularly, but not because of a fortuitous thing like the coronavirus."

Most teachers look at ICTs as something to be explored in the future to keep regular communication with students, to be used as e-learning in some curricular units (about general and veterinary-specific basic subjects), and as another possible studying tool for students (recorded audio or video files from online lectures). Only Director 4 and Teacher A clearly said that ICTs are worth exploring as a way to enable student-centered practices if, for example, video and audio files and/or even computer-assisted learning to simulate medical and biological processes in animals could be used as a way to show students what and how to do the several clinical and surgical procedures.

Students look at the pandemic and online classes as an opportunity to review and modernize the curriculum of some curricular units and to continue online lectures in curricular units about general and veterinary-specific basic subjects, thus reducing their schedules (with less time spent commuting and on campus) and increasing the time available to study. One student added that COVID-19 also increased the voices of students not only in class but also in institutions. However, students are worried about the cancellation of hands-on sessions and claim that the real impact of the changes introduced in veterinary programs because of the pandemic outbreak on their training remains to be seen in the future.

As for the members of the Professional Order of Veterinarians, the pandemic outbreak could be an opportunity to invest in online lectures in the future not only for students enrolled in veterinary programs but also for professionals as a way to incentivize an increase in veterinarian qualifications and knowledge, even among professionals who work and/or live at a great distance from higher education institutions with veterinary programs, and to implement new teaching practices. This last perception was also mentioned by Director 4, who considers this scenario caused by the pandemic outbreak an "opportunity to teach several disciplines using student-centered and ICT-enabled learning methods as encouraged by the Bologna Declaration."

4. Discussion

The analysis of the veterinary programs' curricular plans shows how similar they are. All six institutions follow EAEVE guidelines to maintain or achieve accreditation, which explains the resemblance in CU and ECTS credit distribution. They have more CUs and ECTS credits assigned to the area of the clinic because veterinarians worldwide, EAEVE included, are responding to societal changes such as the process of animals' humanization. This new paradigm of considering pets as part of the family and all animals as sentient beings is causing rapid developments in veterinarian medicine and also appealing to a higher number of students drawn to the desire to help and take care of animals.

Considering the main objectives of the five institutions and their professionals—to train autonomous, resilient, and pro-active veterinarians fully capacitated to identify and solve problems—and the pedagogical practices described by most of the interviewed teachers that highlight how should students have an active role in their learning process while being guided by the teachers, we can consider that veterinary programs include some of the characteristics of student-centered learning models. There is a gap between the first two years of veterinary programs, when the curriculum is not always up to date with the developments in veterinarian medicine and teachers tend to implement traditional teaching and learning practices because they focus on transmitting their knowledge to students; and the last three years when teachers and students seem to be engaged in different teaching and learning practices: solving real-life problems, discussions, researching, and experimenting in different veterinary subjects and with several different animals. This could be explained by the fact

that in the first years, according to teachers and students, veterinary programs focus on general basic subjects (such as chemistry, deontology, and biology) and veterinary-specific basic subjects (for example, animal anatomy and epidemiology). This shows that teaching and learning practices in veterinary programs [17,19] go from mainly traditional in the first years to more student-centered in the last three when hands-on sessions generally begin to be a part of students' daily life on and off campus. We must also consider the signs of frustration among many of the interviewed teachers regarding students' skills and willingness to engage in student-centered practices: not knowing how to search and validate information and focusing on memorization instead of building knowledge are some examples. This makes us think that student-centered learning models require both teachers and students to change their practices, which makes OECD guidelines for basic and secondary education [3] crucial. Students will become more autonomous and the masters of their learning processes if they acquire the right skills during basic and secondary education.

Looking at the five institutions included in this study, we found that the use of ICTs is, at an institutional level, incentivized as an administrative and communication tool as defined by Ellison [21]. There are no signs that these institutions ask their teachers to increase the use of ICTs as part of their pedagogical practices besides the training students must have with specific equipment for the practice of the veterinary profession. The analysis of the instructional use of ICTs in veterinary programs confirms the results of the studies mentioned before [5,9,26,32]: ICT-enabled learning models remained incipient before the COVID-19 outbreak. Of course, we must also mention that in veterinary programs, students learn how to use equipment and technologies (such as x-rays and magnetic resonance imaging, for example) as part of their training, and in these cases, specific technologies are used by teachers as part of the pedagogical practices. But these specific technologies are usually part of teaching and learning practices in hands-on sessions. During lectures, ICTs were not used to implement innovative or even midway instructional practices [27].

The COVID-19 outbreak showed that only one institution and one interviewed teacher amongst the 15 that were interviewed were ready to transition to online lectures. All others had to adapt after the outbreak happened. The fact that one institution was already equipped with a platform that allowed lectures online but that no teachers that we know of used that instrument to dynamize innovative teaching and learning practices, even to solve the problem of having too many students to divide between all hands-on sessions, shows that having the right equipment and instruments available is not enough to implement innovative teaching and learning practices.

Results show that curricular units about general basic and veterinary-specific basic subjects are more easily transformed in online lectures and that some subjects are also possible to organize in ways that can provide students with some skills training: solving real-life problems and visualizing technical procedures are examples. However, all teachers and students found it difficult to teach and to learn about surgical procedures because they had no way to experiment with how to apply the clinical or surgical procedures with their own hands. ICTs that were used were considered important in the context of the pandemic, but teachers and students hope to get back to real hands-on sessions. This could be a result of the limited available ICTs—the internet, platforms, image databases, and audio and video files.

The main negative perception about the changes imposed by COVID-19 in veterinary programs from all actors—teachers, students, and the members of the Professional Order—concerns what they designated as major losses in the students' education because of the cancellation of all practice sessions and internships. Even teachers that were able to somewhat replace parts of the practice sessions during online lectures say that it is impossible to teach and to train the right postures and procedures, and the correct use of instruments to apply in clinical and surgical procedures through online lectures. We might consider that the incipient use of ICTs before the outbreak and the lack of modern technologies in institutions (not considering veterinary-specific equipment) certainly did not help teachers to find innovative solutions to continue hands-on sessions online with minor changes, such as, for example, remote shadowing during services (clinical and surgical) that remained active

in campus facilities. It would be interesting to consider the use of more advanced ICTs in veterinary programs such as virtual environments, 3D images, artificial intelligence, automation, and robotics, for example, that could provide students the possibility to train all kinds of technical procedures in several different animals. This could also be a way to guarantee a complete set of skills in diverse animals to all students across national territory. Not only would institutions stop being dependent on the animals, partners, and equipment available to train their students, but the recent ethical issues surrounding animal welfare and animal rights would also be solved. This is a vision of ICT use that is far from most interviewed teachers and students who look at ICTs mainly as communication tools.

However, this pandemic is also seen by the actors as an opportunity to improve. Most of them agree that curricular units about general and veterinary-specific basic subjects could continue as e-learning. Students feel this could be a way to keep them focused on lectures and save them time to study, both teachers and students claimed that it increased the communication between them, and teachers and members of the Professional Order think online lectures can be used to help students study. As for curricular plans, only the students think of distance education as an opportunity to review and modernize the curricular plans. Only a few teachers said that curricular plans must be reviewed regularly because of the rapid developments in the area and to respond to societal changes, refusing the idea of making changes just because of the pandemic outbreak. What some teachers and the members of the Professional Order of Veterinarians see is the opportunity to explore new teaching and learning practices enabled by ICTs such as digital files and computer-assisted learning to implement innovative learning models.

5. Conclusions

Before COVID-19, all veterinary programs were dynamized through learning and teaching practices from traditional learning models, or teacher-/curriculum-centered, in the first two years and closer to student-centered models in the last three, which concentrate most of the hands-on sessions (practice sessions and internships). Veterinary programs, especially during the last years, are characterized by the regular use of teaching and learning practices that place students in the center of the learning process and give teachers the role of mediators. Specific veterinary technologies are used during hands-on sessions, but the use of ICTs in lectures mainly replicates traditional teaching practices, and the actors' speeches do not contain references to innovative practices or to the use of ICTs as enablers of innovative teaching and learning models during lectures.

So, how did teachers and students of veterinary programs adapt to distance education? The answer is both well and not so well. According to the actors, the transition of lectures, particularly in curricular units about general and veterinary-specific basic subjects, was smooth and even accompanied by some positive signs such as, for example, better communication between students and teachers and an increase in the students' focus and participation during lectures. We can consider that it was a good experience that most believe should continue in the future. It would also be a way to provide extra education and knowledge refreshment and updates for active veterinarians and increase the possibility for them to access those programs, especially those who live and/or work far from any of the current seven institutions.

But there is also a negative answer to that question. All interviewed actors mention that the cancellation of all hands-on sessions (practical sessions and internships) due to the pandemic outbreak represents major losses for the students who are enrolled in veterinary programs. As we observed, some teachers found ways to replace part of some hands-on sessions because some teaching and learning practices are easily dynamized through online lectures (solving real-life problems, researching, and validating information, for example). But the real problem came when it was time to allow the students to experiment and to train in clinical and surgical procedures: how to use the instruments correctly, how to deal with animals, how to communicate with animals' owners, and how to readapt the procedures if necessary. ICTs such as learning to simulate medical and biological processes in animals, virtual reality, and even simpler equipment such as video cameras shadowing teachers

while conducting real-life procedures in animals could have been helpful but were not considered. The incipient use of ICTs and the lack of more advanced equipment were certainly barriers.

Teachers, students, and the members of the Professional Order were alerted to the need to increase investment in innovative teaching and learning practices in the near future, and some teachers manifested a wish to further explore the use of ICTs to enable innovation in veterinary education.

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The Interaction between Higher Education Institutions and Professional Bodies in the Context of Digital Transformation: The Case of Brazilian Accountants

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Abstract: The business economy experienced major changes during the last three decades. The social and economic globalization associated with the fourth revolution put the accounting profession under great pressure toward harmonization and convergence. Still, the route to become a qualified professional accountant varies from country to country all over the world. This paper seeks to understand the evolution of the accounting profession in Brazil and focus on the interaction between higher education institutions (HEIs) and professional bodies, in the context of digital transformation. It is an exploratory study. A survey questionnaire was used to collect data about the perception of the directors of first-degree programs regarding the autonomy of HEIs in defining the curricular contents intended to qualify accounting professionals. The findings show that HEIs are highly influenced by the professional order and Ministry of Education. The limitation associated with this research is that it focusses on one particular professional group in one country.

Keywords: accountant; professions; digital; professional bodies; higher education institutions

1. Introduction

Globalization has effects on the environment, culture, political systems, development and economic prosperity, as well as on the welfare of human beings that make up societies around the world. Technology has been the catalyst that has propelled another globalization process. The progress made, especially in the field of information technology, has dramatically transformed economic activity.

The fourth industrial revolution has changed the landscape of education and innovation. Higher education institutions (HEIs), businesses, professional associations and public authorities will have to cooperate in the next framework of Industry 4.0. This term was introduced by Kagermann et al. at the Hannover Fair in Germany in 2011. The emergence of Industry 4.0 is driven, not only by the rapid development of technology, but also by social and economic factors. Key technologies driving Industry 4.0 are wearables, augmented reality, simulation, autonomous vehicles and robots, additive manufacturing, distributed ledger systems (such as blockchain), big data analytics, mobile computing and cloud computing. These technologies affect and enable the creation of different novel business models [1–4].

In addition, there are also social and economic factors driving the fourth industrial revolution, such as emerging platform economies and more freelancing and consultant-style services, which are enabled by technology. While, at the same time, more and more people are getting accustomed to a new flexible kind

of work, it also means that work relationships are becoming more interdependent [5]. The development of up-to-date curricula compatible with current market requirements, namely those required by Industry 4.0, requires collaborative networking, where the various actors, namely universities, companies, professional associations and the state, are represented. The digital transformation of society pressures professions to adapt to the traditional framework of professionalism by including attitudes and behaviors expressed in the digital world.

The professions have evolved from a "golden age" of professionalism to a loss of professional dominance and influence, partially caused by managerialism [6–8]). Over the past four decades, the increase in higher education courses, replacing the old professional training programs, has been growing, due to the knowledge and skills that involve the qualification of future professionals. In this scenario, HEIs (universities, colleges, polytechnics) provide knowledge and certify the technical skills of professionals, sustaining their ability to solve problems and guide their clients [9]. University autonomy and academic freedom are closely related; however, they form different concepts. According to [10], the first is an institutional authority; the latter is a personal privilege granted to academics to safeguard the unrestricted pursuit, transmission and dissemination of truth and knowledge. Still, according to the same author, the following concept is an interpretation of the historical roots of these concepts and, in particular, how the determinant concepts of university autonomy have evolved in response to changes in opinion about education. The author of [11] starts from the claim that the result of higher education, in the first place, is the credentials in which knowledge is obtained, mainly, in professional life.

Although such perspectives have significant consequences for the understanding of the characteristics of professionalism, it is not yet clear how professional competence is acquired. In the social and human sciences, professions are presented as a phenomenon of the organization of the labor market, given the ability to create exclusive shelters for performance, through the monopoly of advanced knowledge and other credentials, which are necessary to achieve social and economic opportunities of authorized practices [12–14]. In addition to this concept, [13] observes that the control of exercise and professional power is guaranteed by universities, the state and professional bodies, which support professional power from three pillars: autonomy, monopoly over knowledge and credentialism. Still, according to [15], the result of the professionalization process is seen as the achievement of "professional autonomy".

In this context, the problematization of this study is formulated in the following terms: which are the main influences that Brazilian HEIs suffer regarding the definition of the curricula of higher education courses in accounting? Similar to [16], this paper seeks to understand how various human actors including the accounting profession, the state, universities and accounting academics, along with non-human actors such as accreditation, regulation and transformation, interact for the setting of syllabi or course content to prepare future accounting professionals.

In the following sections, we look for a deeper understanding of how professional bodies interact with universities. The next section introduces the theoretical framework adopted in this paper. In Section 3, we describe the methodology and premises of the study, followed by Section 4 with the presentation and discussion of the results. Finally, the conclusions and perspectives for the deepening of the theme with a proposal for further studies are presented.

2. Theoretical Approach

The term professionalism is applied in many different circumstances. To understand the vagueness of the concept, we must go back to [17], who identified a professional as a person whose time is mostly dedicated to an activity, unlike that individual whose involvement in a particular occupation is transient or provisional. The authors of [18] emphasize that a profession emerges when a defined number of people begin to practice a defined technique, based on specialized training. Thus, categories of daily life are confused with the ways in which they exist in social life, in the context of real groups and the aspect of formalization, starting from the state, granting professional status.

According to [19], the initial development of the fundamentals of the study of professions, in large part, arose in North America, with a focus on the United States. The traditional method of self-regulation, which characterized major professions like medicine, was based on legal devices of exclusive licensing and certification and involved protection from naked economic and political pressures and from competition with other occupations [20,21]. The assumption was that with such protection, the professions would be both willing and able to regulate the performance of their members themselves, by placing the public interest over collective and personal advantage. It was presumed that under these circumstances, professionals would work ethically and competently.

Professions are presented, according to [20], as a phenomenon of market organization, in specific areas of work, due to higher education knowledge and the monopoly of knowledge and credentials, delimiting the performance of individuals who do not have the requirements required, and who are not allowed to present themselves as professionals. In the contemporary literature, the term profession is approached in line with certain legal categories, such as lawyers, doctors and engineers, in the form of specialized activities, which gives them a high status, power and prestige [13,20]. Occupations, on the other hand, are transient or provisional activities, without specific knowledge, which do not require training and are carried out autonomously, even in the face of remuneration [18,22]. Still, as mentioned by [20], the formal education required is the milestone that distinguishes occupations from professions. That is, something like a form of accreditation, which acts as a market reserve mechanism. According to [13] and [14], aiming to achieve status as a professional, in addition to the inherent knowledge, the graduate must comply with other requirements, among which are the credentials in the form of a degree and, in particular, approval through a knowledge test applied by the respective order or professional council. Thus, in both cases, the "power" of a profession to identify and safeguard the content and practices of its work influences its evolution and status in the system of interdependent professional relationships [23].

The assumption was that with such protection, the professions would be both willing and able to regulate the performance of their members, by placing the public interest over collective and personal advantage. It was presumed that under these circumstances, professionals would work ethically and competently. However, this traditional method of self-regulation is changing. It is being replaced by methods intended to impose stronger, external controls which [21] are classified into three forms, as follows:

- The first one is *market* regulation, which is usually labeled as "deregulation". Professionals are exposed to the market. This can be done by promoting interprofessional or intraprofessional competition.
- The second form of regulation pointed out by Freidson is *bureaucratic regulation.* Such regulation is characterized by a proliferation of record-keeping requirements and the development of systematic methods to review those records. Embedded in that system of records, facilitated and accelerated by the computer, is a rationalized system of categories by which professional work becomes measured and assessed.
- *Collegial regulation*, the third method of regulation identified by Freidson, becomes more clear, active and formal. In the case of accounting, accountants were required, first, to review their colleagues' working processes and decisions. For the author, collegial regulation rather than external bureaucratic regulation remains predominant.

In charge of legitimizing the professionalization process, the formal structures are represented by universities, professional bodies and the state. The organization of professionals around associations and orders originates from what [13] lists as the first function of professionalism: the protection of standards of excellence in the face of pressures of speed or ease, in which such a function is performed in the development of expertise, with autonomy, which results in the belief that qualified professionals are qualified in determining the functions to be performed, in dedication, based on the concept that through the development and exercise of expertise, they are worthy of devotion to a career. In this context, professional associations and orders operate between the state and professionals and between

them and their clients, who participate in the construction of rhetoric and discourse, aiming at public recognition and legal protection. The debate in relation to the performance and prerogatives in favor of professional orders also involves questioning the legitimacy delegated by the state, in its own powers, based on the argument that in some countries, there is no mandatory registration of professionals, in the respective orders [24,25]. On the other hand, in countries like Spain, England and Brazil, the legislation has greater requirements, since certain orders, such as accountants, doctors, engineers and architects, fulfill a supervisory role.

In the context of sociological theories, studies on professions, within a critical perspective, do not recognize professionals as neutral altruistic groups, but in the form of aggregates with identical interests and who seek market control, in addition to their central role in capitalist mediation and the means of production [26]. Indeed, functionalist theorists of professions were heavily criticized. Their scientific support, mainly their ideological neutrality, was questioned. Professions underwent "crises of confidence and accountability" [27] which created the basis for new approaches. The paradigm of power (Freidson, Johnson, Larson) opens up a debate between the theses of *professional power dominance* and *professional power decline*. The ideal type of [28], i.e., professionalism in its pure sense, no longer exists, or rarely exists. It is now organizationally defined and includes the logics of the organization and the market, managerialism and commercialism. The authors of [29] argue that the discussion about professionals and scientists working in formal organization revolves around the issue of control, namely, whether or not conventional bureaucratic methods are appropriate or practical for controlling the work of scientists and professionals. Indeed, as stated by [30], "professional work is increasingly mediated by organizations; many professionals now work in corporations or government offices; most professional services are delivered to organizations rather than individuals; and professional service firms have become complex, diversified organizations that are often larger than their Fortune 500 corporate clients".

According to the set of publications present in the contemporary literature aimed at professions, its field of study remains attractive for research, related to the theme, notably as regards educational and training aspects, the specific knowledge required, state interference and the actions of associations and professional orders [31,32]. Indeed, as stated by [33], "there exists a large and well-established body of research which has shown that the process of becoming a professional involves much more than simply passing examinations and being registered to practice".

The accounting profession, whose prerogatives involve acting in relation to the accounting of organizations with economic activity, in the context of liberal professions, does not belong to the group of so-called "imperial professions" whose identification is attributed to law, medicine and engineering [34]. Although, in recent times, some of them have had to adopt more flexible ways of acting, instead of legally supported and socially legitimized claims [35]. Additionally, the same author already identifies accounting as a liberal or collegial profession.

Historically, the recognition of accounting, as a profession, initially occurred on the European continent, when the first accountants obtained their status legitimately, based on the significant role played by the state in aiming its development as a profession [27,36–38]. In addition to the powers and prerogatives delegated by the state, professional accounting associations and orders, in many countries, including Brazil, the United States, Japan and Portugal, for example, take care of the preparation and application of the evidence required for access to the professional category and the performance of its affiliates, namely [36,39,40], regarding the code of ethics and ontology.

In Brazil, the 1988 Federal Constitution expressly enshrined the principle of university autonomy. Autonomy is generally understood as the capacity to be governed by specific laws [9]. In practical terms, society entrusts HEIs with the task of building and disseminating scientific knowledge so that, through the state's delegation, it can decide on the appropriate technical–scientific training, which allows future professionals to be prepared for their performance in the market [41]. Additionally, within the scope of Brazilian legislation, comprising the Law of Directives and Bases of Education (LDB), concomitant with Article 207 of the country's Federal Constitution and with the text of Resolution 10/2004 of the

National Education Council (CNE), it is expressed that HEI directors, operating in the country, have didactic–scientific autonomy to structure the curricular content of higher education courses, including undergraduate courses in accounting sciences [42]. Regarding the management of these higher education courses, this is the responsibility of a teacher, called the director, with a master or doctor title, elected or appointed to the position according to the current guidelines, issued by the Ministry of Education and Culture [43,44]. Regarding accounting teaching in higher school, this autonomy is hard to manage, since the performance of accounting science students is periodically evaluated in the tests of the National Student Performance Exam (NSPE) and at the time of the professional access tests, applied by the Federal Accounting Council (FAC) and called the Sufficiency Exam. Based on the above, it is observed that the Brazilian HEIs, which have the privilege of autonomy in the elaboration of their curricula, face two different situations: the first, in relation to the autonomy itself, which allows them to define their own educational and the second, in view of the consequences that this autonomy can bring, since when shaping their curricula, they need to act to guarantee the success of their graduates [45]. Therefore, curricular components and didactic–pedagogical issues are subordinated to two external evaluation parameters: NSPE, from the National Higher Education Assessment System (SINAES) and the Professional Order Examination, called the "Sufficiency Examination".

3. Materials and Methods

In this context, the problematization of this study is formulated in the following terms: which are the main influences that Brazilian HEIs suffer regarding the definition of the curricula of higher education courses in accounting?

In Figure 1, we represent the framework followed in this research. In the context of open economies and digital transformation, the rise of the market introduced important changes in the way universities interact with professional bodies. In particular, professional organizations and their increasing power are connected to processes of professionalization dictated by the market and highly influenced by the digital transformation of society, based on the assumption that professional behaviors are defined by society, culture and generations [46].

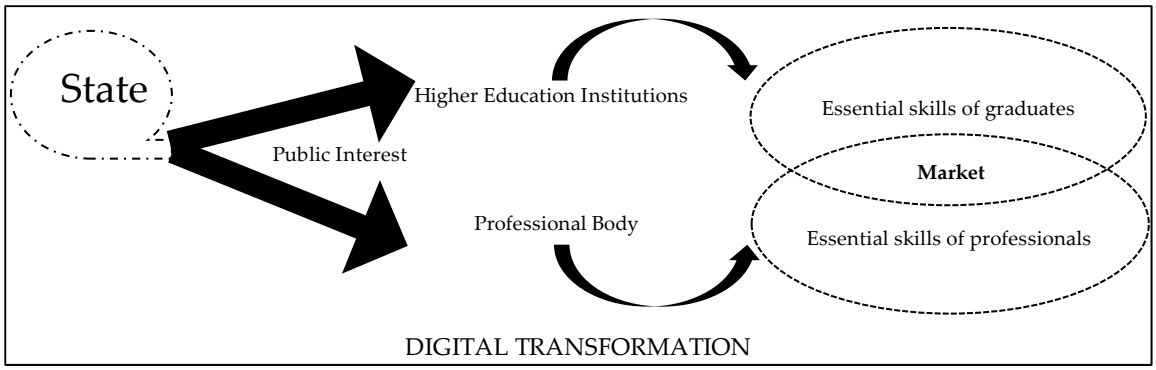

Figure 1. Research framework.

Our framework recognizes changes and continuities within the increasingly competitive context in which professionals operate. So, in order to know the perception of the directors of the higher courses in accounting sciences in relation to the way HEIs and professional orders interact, they were asked about three premises, in which they expressed their opinion from five options: (1) strongly disagree, (2) partially disagree, (3) indifferent, (4) partially agree and (5) totally agree.

- P1. The knowledge provided by the university is the main pillar of the training of future accountants, as it allows it to build the profile of the ideal professional type and to develop the essential skills for the exercise of the profession.

- P2. Universities, as accredited to qualify future accountants, are instrumentalized by professional orders, aiming to legitimize their own existence.
- P3. The curricular matrix adopted at the HEI in which I work; in view of the implementation of the Sufficiency Exam in 2010; needed significant adjustments in the subjects covered in the exam.

Aiming to confirm the perception of the directors in relation to the starting point, they were motivated to point out the degree of influence in relation to participation in the definition of the study plan (contents/pedagogical methods/curriculum), of the following drivers, already identified in the theoretical framework of this article: (a) defined by the HEI itself; (b) national curriculum guidelines; (c) Federal Accounting Council; (d) content present in the FAC Sufficiency Exam; (e) suggestions from the course faculty; (f) UN/UNCTAD/ISAR guidelines and; (g) regional features.

For data collection, a questionnaire was used. The population of this study comprised all 980 directors of accounting sciences in Brazil, identified from a report provided by the FAC, in January 2014. The sample is represented by 436 responses obtained from questionnaires sent electronically, through the tool ''Google Docs" and to confirm its validity, the formula proposed by [47] was used to calculate the error of proportions in finite populations. Data collection was completed in December 2014, and the systematization of data began.

4. Presentation and Discussion of the Results

4.1. Brazilian Settings

In order to understand the interaction between higher education institutions and professional bodies regarding the construction of curricula of the course for future accounting professionals, one should first know the political and institutional settings of the Brazilian accounting profession.

Higher education institutions operating in Brazil and offering higher education in accounting sciences must follow the legislation of the Ministry of Education (MEC), in the form of Resolution no. 10/2004 of the CNE. In this rule, the body of knowledge that makes up the formation of the future accountant is based on this resolution [42]. However, it is necessary to note, at the outset, that in Article 1. of this legal document, there is reference to the National Curriculum Guidelines, to "[...] be observed by Higher Education Institutions", that is, there is not an imposing term in that article, but in the sense of observing the precepts listed there. According to [48], these bases do not define, in general, the mandatory subjects common to all courses. According to the same authors, there are guiding principles—or something like axes, of teaching areas—from which each HEI has autonomy to develop its curriculum. As for the guiding principles provided for in Resolution no. 10/2004 of MEC, these deal with the formation of the desired professional profile, in the context of skills and competences; the curricular components of the courses; the student assessment system and the course, in addition to the topics linked, for example, to the supervised internship, complementary projects and activities [48,49] that bring the activities of international organizations to the agenda, for which the training of competent professionals is one of the objectives of accounting education, in the context of professional organizations. Among these, the International Federation of Accountants (IFAC) through the International Accounting Education Standards Board, has acted with emphasis, aiming to create a standard reference in accounting education, with the new attributes that future accounting professionals need to develop, starting from the proposition of the American Institute of Certified Public Accountants [50], which are related to strategic and critical thinking, which propose the adoption of a perspective of global understanding, in view of the legal and tax implications in business, with a focus on clients and in marketing, with the ability to make use of technologies.

From the conceptual review carried out in this article, it appears that the curriculum content proposals for the training of accountants, from those presented by Association of International Certified—Professional Accountants—AICPA and International Federation of Accountants—IFAC and United Nations/United Nations Conference on Trade and Development/International Standards of Accounting and Reporting—UN/UNCTAD/ISAR form a set of curricular guidelines. In addition to these, the proposal

of the Brazilian Accounting Foundation and the Federal Council of Accounting, to the legal text of Resolution CNE nº. 10/2004 of the MEC, constitute the so-called "drivers", i.e., influencers, of the accountant's training.

Society, likewise, with its particularities, together with the clients of accounting services, present themselves as drivers. The existing influences are part of the composition of the curriculum aimed at training the professional, along with others, that may occur. As a result of the conceptual and theoretical development, it is inferred that there is a set of organizations, which can interfere in the composition of the curricular contents intended to train accountants in Brazil, namely:

(i) the Higher Education Institution itself;
(ii) national curriculum guidelines;
(iii) contents present in the Sufficiency Exam of Federal Accounting Council;
(iv) regional specificities;
(v) suggestions from the faculty;
(vi) guidelines of United Nations/United Nations Conference on Trade and Development/International Standards of Accounting and Reporting;
(vii) proposal for a new curricular matrix, based on the Federal Accounting Council/Brazilian Foundation of Accounting.

As already mentioned, HEIs have the freedom to structure the curriculum content for accountant training. However, such freedom, from now on, is limited to the contents that make up the NSPE and the Sufficiency Exam itself, which is why both are placed as limitations and restrictions. A concern with these limitations involves the imbalance between external financial reporting, for the purpose of statutory and regulatory compliance with government agencies, and internal management accounting, for the purpose of providing managers and executives of a company with insights to make decisions. Today there is greater emphasis on external financial reporting relative to internal management accounting. This imbalance adversely affects organizations in terms of improving their performance to benefit their stakeholders.

This set of curricular guidelines, designed to support the training of future professionals in Brazil, including aspects related to ethics, management controls and citizenship orientation, is largely related to that contained in the International Education Standard 2 and issued by the IFAC [49]. In this way, students acquire knowledge, skills, values, ethics and professional attitude, with the ability to integrate such elements, using the professional accounting education program to develop their professional skills.

It is also necessary to note that the demands of the labor market in the accounting area, in the Brazilian scenario, have converged to a deeper look at the teaching of accounting [49] and this concern is justified by the nuances of the business field, considering the current economic situation in the world context. Among these changes, in the academic and corporate environment, the process of convergence to international accounting standards stands out, with the signing of Law no. 11,638/07—Brazilian Corporate Law and Law no. 11,941/09, concomitant with the technical pronouncements, issued by the Accounting Pronouncements Committee (CPC) as of 2008 [51].

It should also be noted that organizations, companies and users of accounting services are customers of accounting education, seeking to meet their needs based on the skills, abilities and attitudes of students trained by HEIs. Such action requires interaction between the education offered and the demands of the world of work, in order to minimize the problems of accounting education [52,53], in addition to considering that the work environment in which the professional is inserted, with its regional particularities, becomes a competitive differential for users of accounting information, for professionals and HEIs themselves. Taking into account the legal aspects that need to be met in the training of accountants and concomitant with the contributions already listed in this article, it is possible to identify a set of drivers that tend to influence the curricular structure of accounting courses in Brazil, in line with the objective proposed.

Based on the current curricular guidelines and other items of the MEC legislation, the HEIs have autonomy in the construction of the curricula of higher education courses [47,48]. In the same legal context, concomitant with the studies that highlight the main duties of the course coordinators, their performance, together with the collegiate of the course, includes the task of organizing the full curriculum of the course, after hearing the faculty [43]. Thus, they become the first curricular drivers of accounting science courses: the HEIs that offer the course, its coordinators and the respective collegiate of the course.

Instituted by Law no. 10,861/2004, the NSPE is a mandatory curricular component, whose test is applied to graduating students every three years. The sample is made up of academics who, by the month of July, have completed more than 80% of the minimum workload of their curriculum, or will stick to a degree by the end of July of the following year. The tests are applied by the National Institute of Educational Studies and Research Anísio Teixeira—INEP [54,55].

According to Ordinance no. 202/2012, the NSPE's general objective is to evaluate the performance of students in relation to the syllabus provided for in the curricular guidelines, the skills and competences for permanent updating, of knowledge about the Brazilian and global reality and about other areas of knowledge [56]. Even if it is a mandatory curricular component, the individual result obtained by the student does not have the possibility of failing, but it contributes to the evaluation of the HEI and the respective course, without being linked to the Sufficiency Exam, applied by the Federal Council of Accounting [55].

The NSPE test takes as a reference a professional profile that includes scientific, technical, social, economic and financial issues; that has logical reasoning in the face of different scenarios; that manifests critical–analytical capacity and quantitative reasoning and has a systemic and holistic view. It must also be able to demonstrate critical–analytical capacity in relation to the activities of investigations, audits, expertise and financial, patrimonial and governmental quantifications [31].

In addition to these qualities, the future professional will be assessed on their ability to generate information for management processes for performance improvement, on the development of information systems, and on the understanding and ethical conduct in the professional practice, and even if they are not selected for the NSPE tests, they must perform the Sufficiency Exam, if they want to obtain the professional registration.

Under current Brazilian law, graduates who wish to access the category of accountant must provide, from the 8th semester of the course or after graduation, the tests that make up the Sufficiency Exam. Having completed his graduation and obtaining approval in the exam, he/she will be able to submit the professional registration with the respective Regional Accounting Council [57]. The Sufficiency Exam aims to ensure that the professional has minimum knowledge for entering the profession and, according to [56], the registration itself is not just an endorsement for the professional to perform his duties, but represents, above all, the protection of society from bad professionals, from people without training exercising their profession, from the risks that are involved in a lack of inspection and from many other factors that compromise the quality and trust of the services provided. The application of the Sufficiency Exam results from Law no. 12,249 [57], and the exam has become mandatory, and accountants could have professional registration only if they pass the exam, without exception. the Sufficiency Exam is of four hours' duration and is composed of fifteen multiple-choice questions. The Federal Council of Accounting (FCA) is in charge of its preparation and it counts on the collaboration of academics, nominated by the FCA. The first test, in 2011, brought to the agenda the study and adaptation of the disciplines and content that make up the curricula, then offered, in light of the new requirements of the exam [51]. There was also a need to include the contents resulting from the changes that occurred in the harmonization of international accounting standards, the new Brazilian Corporate Law and the creation of the Accounting Pronouncements Committee.

The institution of the Sufficiency Exam, as a requirement for the registration of professionals, is configured as another way of safeguarding the market against the untrained, protecting society and customers who use accounting services, verifying if students, even those away from the labor market,

hold the average knowledge necessary to exercise the profession, in line with the syllabus, made available during the accounting sciences course [37,58]. Therefore, it does not constitute proof of training, but aims to prove whether the training obtained by the future professional was sufficient to enter the profession. However, given the nature of the course and its guidelines, aspects questioned by [59], for whom the contents are present in the Sufficiency Exam, as well as the level of approvals, given the requirement of 50% of correct answers, do not allow for acting as accountant or financial advisor.

In addition to the NSPE and Sufficiency Exam tests, the contemporary literature allows us to identify other possible drivers. One of these comes from the Brazilian Accounting Foundation [60] in the form of a national content proposal for undergraduate courses in accounting sciences, together with the Federal Accounting Council (FAC). The objective of this joint proposal from the FBC and the CFC is to create a new curricular matrix, with the contribution of professors and directors of accounting courses, from HEIs all over Brazil, aimed at HEIs that offer the accounting sciences course [60]. In addition to the FAC/BAC proposal, others are identified, including those from international organizations.

Other international organizations, such as IASB and IFAC, have presented suggestions for the regulation and harmonization of higher education in accounting, through a joint proposal for a global curriculum model, suggested as a benchmark for accounting professionals [61], aiming to standardize the qualification of accountants in all countries.

In order to reduce the disparity in accounting education in the world, the UN/UNCTAD/ISAR presented a curriculum suggestion so that the higher courses in accounting sciences can support their curriculum, so that the graduates in accounting sciences receive training in that the knowledge necessary for the profession be similar, regardless of country [61,62]. In the text, UN/UNCTAD/ISAR presented a study plan model, published by TD/B/COM.2/ISAR/6 in 1999 and revised in 2003 [63] through the document Revised Model Accounting Curriculum, by means of a detailed description of the contents of each of the knowledge blocks.

Even though the processes of globalization are challenged cultural identity and expression in a number of ways, national accounting systems are strongly influenced by local culture. Actually, as recognized by [64], "different values of cultures preventing unified accounting practices globally are perceived to have influenced accounting values nationally and internationally". In this context, a unified exam appears as a utopic idea. Nevertheless, those who are able to take an active part in global cultural exchange often experience culture as a process rather than as a product and, in that sense, maybe we can talk about a tendency for unification regarding "accounting professionalism" [64].

4.2. Coordinators' Perceptions

Supported by three premises and one more question directly linked to the starting question, the systematization of the answers obtained allowed for visualizing the perceptions of the coordinators of the higher courses in accounting sciences in Brazil, in relation to the objective of the study, which aims to identify which organisms, and respective participation, influence the construction of curricular content designed to train accountants in the country.

As for the first premise (P1), the coordinators agree that the knowledge provided by the university is, at the moment, the main pillar of the training of future accountants, since it allows them to build the profile of the ideal professional type, in addition to developing the skills necessary for the exercise of the profession. In this regard, the level of agreement, between partially and totally, is over 90%.

Regarding the second premise (P2), most coordinators agree that HEIs, when graduating students with scientific knowledge at a higher level, are often instrumentalized by professional orders, which use them to legitimize their own existence, to the detriment of preparation of future professionals.

With regard to what is contained in the third premise (P3), there was also agreement on the part of the coordinators, in the majority, that the curriculum adopted in the HEI of performance, from the implementation of the Sufficiency Examination, in 2010, required adjustments and significant adaptations in the subjects whose contents are contemplated in that exam. Although the item of total agreement is not the predominant one in the set of responses obtained, the partial agreement confirmed

that even if not so significant, changes have occurred, to a lesser or greater extent, in a good part of the accounting sciences courses in operation in the country. This aspect allows us to infer, from now on, the importance of one of the influencing factors in the construction of curricula.

In the last question presented to the coordinators and which is directly linked to the starting question, they were motivated to inform about the influence exerted by seven different organizations, in relation to the structuring of the current curriculum of the course. In the table below, the responses of the coordinators indicate the preponderance, individually, of the indicators and their participation in the composition of the curriculum content intended to train accountants in Brazil.

Table 1, below, shows the indicators of influence and respective percentages of participation in the construction of the content intended to train accountants in Brazil.

Table 1. Indicators of influence on the construction of curricula.

Indicators	(%)
Included by Higher Education Institutions	14.70
National curriculum guidelines	17.50
Federal Accounting Council	12.80
Contents of Sufficiency Exam	14.80
Suggested by teachers	17.80
United Nations/United Nations Conference on Trade and Development/International Standards of Accounting and Reporting	9.00
Regional features	13.40
Total	100.00

Regarding participation in the composition of curricular content, in order of importance, it is observed, according to Table 1, that the content included by the HEI itself has a percentage of 14.70%. However, when adding the suggestions of the faculty, it results in 32.5%, that is, the internal influences have considerable importance in relation to the whole.

On the other hand, a percentage of 14.8% coming from the contents present in the Sufficiency Examination brings indications that external aspects promote adjustments in the contents present in the curricula, in line with the answers obtained in the third premise (P3).

Another important piece of information that can be identified in Table 1 is the sum of the percentages corresponding to the indicators that reflect the influence of associations, professional councils and orders, in their various forms (Federal Accounting Council, United Nations/United Nations Conference on Trade and Development/International Standards of Accounting and Reporting and contents of the Sufficiency Exam), which corresponds to 36.6% of the total. Thus, the three pillars of professional training already mentioned in the study: (i) Higher Education Institutions, (ii) State and (iii) Professional orders, have, through their representative bodies, effective influences in the process that leads an academic to the title of professional.

It is worth mentioning that although there is no legal aspect that can guarantee the influence of regional particularities, this indicator has been proved to be relevant, given the differences existing in the various macro-regions of the country, the dimensions of which have already been mentioned in this article. Since the study data were treated statistically and are within the margin of error as mentioned by [48], this allows for drawing conclusions about the information obtained, in addition to responding to the main premise of the study.

5. Conclusions

The accounting labour market in Brazil has been undergoing several structural changes, being influenced by factors such as advances and changes in information technology, regulatory bodies, organizations and globalization [65]. In such a context, accounting is required to go more and more

international harmonization. According to [66], international organizations of accounting, such as the IFAC, the ISAR and the IASB, are pressuring accounting professionals of different countries to develop similar competencies. Indeed, as the authors stated, "it is understandable that the how strong the similarity between the global international curriculum and the local individual curriculum more strong will be the evidence of the harmonization of the accounting education of this country" [66].

This paper investigates factors affecting the HEI's autonomy regarding the curricula of accounting graduation courses. Although there have been many similar investigations in other countries, to the best of our knowledge, we are the first to explore the perception of the coordinators of accounting graduation courses related to this issue in Brazil.

This study demonstrates that the university is perceived as the main pillar of the training of future accountants, since it develops the necessary skills for professional practice, an aspect that is related to what was proposed by [13,20]. However, coordinators of accounting graduation courses find that Brazilian HEIs are instrumentalized by professional orders, aiming to legitimize their own existence, in line with the propositions of [14,32]. Moreover, our respondents recognized that the curricula of the courses they coordinate underwent significant adjustments due to the subjects covered in the Sufficiency Exam in 2010. Therefore, Brazilian HEIs lost autonomy in defining the curricula of higher accounting courses. In line with [16], we conclude that HEIs should take care not to abdicate their responsibilities for the setting of syllabi or course content to professional bodies.

This paper contributes to the literature because it brings knowledge of accounting education in Brazil to non-Brazilian readers, and provides findings that will help HEIs rethink the way they manage their autonomy concerning the curricula's definition. Moreover, as stated by [67], the Brazilian experience is important to a broader international audience because "despite the growing economic and political prominence, little has been published in English language scholarly journals about the accounting profession in Brazil and its educational requirements". It is worth mentioning that the questionnaire applied to the respondents was built exclusively for this investigation, which is a limitation of the study. Moreover, data were collected six years ago. Even though the phenomenon under study is stable, the outdated data limit the interpretation of the results and their utility for practical purposes. In future, validated scales should be used, so the measure of the constructs is more feasible. Moreover, as the literature describes accounting professionals as negatively stereotyped in relation to creativity, dedication to study, teamwork, communication, leadership, propensity for risk and ethics [68], it would be of great interest to investigate the most recent changes in the curricula of accounting graduation courses that develop new competences in these fields. Simultaneously, considering that the current business environment is characterized by regular and substantial transformation and technological advances are accelerating globalization, it would be interesting to understand how local, national and international cultures influence essential hard and soft professional skills required of accountants in each society.

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education sciences

MDPI

Article

A Learning Analytics Theoretical Framework for STEM Education Virtual Reality Applications

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Abstract: While virtual reality has attracted educators' interest by providing new opportunities to the learning process and assessment in different science, technology, engineering and mathematics (STEM) subjects, the results from previous studies indicate that there is still much work to be done when large data collection and analysis is considered. At the same time, learning analytics emerged with the promise to revolutionise the traditional practices by introducing new ways to systematically assess and improve the effectiveness of instruction. However, the collection of 'big' educational data is mostly associated with web-based platforms (i.e., learning management systems) as they offer direct access to students' data with minimal effort. Thence, in the context of this work, we present a four-dimensional theoretical framework for virtual reality-supported instruction and propose a set of structural elements that can be utilised in conjunction with a learning analytics prototype system. The outcomes of this work are expected to support practitioners on how to maximise the potential of their interventions and provide further inspiration for the development of new ones.

Keywords: virtual reality; learning analytics; STEM education; instructional design

1. Introduction

As new statistical data show, STEM (science, technology, engineering, and mathematics) education is expanding rapidly in most developed countries and thus, the necessity to provide learners with well-designed instructional contexts becomes even more imperative. This statement is aligned to the outcomes of previous studies [1,2], which stressed the importance of assisting learners to understand the acquired knowledge in-depth, albeit the difficulties that instructional designers face when preparing specific laboratory exercises (including experiments and practice-based tasks) pertinent to the STEM fields cannot be easily disregarded. For instance, field-based experiments require complex transportation to different locations whereas some of the laboratory-based tasks may be too dangerous (e.g., an electric shock caused due to the incorrect wiring of electrical wires in an electrical engineering course) or too expensive to be performed in the real world (e.g., use of hard-to-acquire specialised equipment). Additionally, the limited training, or the lack of awareness that students may have on matters related to lab safety and security further increase the risks for injuries or even fatalities [2,3]. To prevent such issues from occurring, the presence of the instructor is essential however, even then, the limited attention that individuals receive—e.g., due to the time-management constraints—has been reported as a factor causing negative emotions and behaviour (e.g., frustration, dissatisfaction) [3,4]. Such shortcomings are linked to serious complications towards the theoretical knowledge development or the conceptual experience advancement when abstract topics are under consideration, and that may hinder students' confidence to apply such practices in the future [5].

A proposed solution to eliminate the impact of such drawbacks considers the adoption and the integration of interactive technologies which can make the educational processes more efficient and effective [2,6]. This is also aligned to the route that wants employees to be undertaking frequent training tasks in simulated environments [7,8]. As a result, the need to analyse the potential and the shortcomings of the computer-supported instructional strategy is of critical importance [9].

However, understanding how to maximise the effectiveness of the instructional design strategy, based on the theory that each STEM subject imposes, is a complicated and demanding process. The solution to this matter is identified in the potential that the technological tools (per se) offer several opportunities for the collection of large datasets which can provide information related to the educational context, the utilised instructional strategy and the behavior of the learners. Therefore, by collecting and interpreting such information, content and instructional designers as well as researchers and educators can increase the effectiveness of the learning strategy, facilitate the learning process, and prevent the development of misconceptions [10,11].

Virtual reality (VR) has been steadily gaining momentum in STEM education as researchers, educators, and industry practitioners tend to design and develop more and more applications that promote experiential and active learning; as opposed to the traditional teacher-centered (passive) approach [1,4]. In addition, under the aid of third-party equipment—such as cave automatic virtual environments (CAVEs) or head-mounted displays (HMDs)—users are free from external distractions and can thus, achieve greater levels of immersion. Relevant studies [5,6,9–12] have concluded that the *high representational fidelity* of the graphics affects the *realism* of the activities and thus, leads users to develop the so-called *sense of presence*. Sense of presence or, otherwise, immersion has been correlated with positive learning outcomes and results (e.g., attainment of different learning objectives, cultivation of cognitive thinking skills).

However, despite the increasing movement towards evidence-informed VR-supported instruction, very few systematic efforts can be identified to date where applied learning analytics (LA) practices are discussed. In addition, no concrete solution exists to analyse and present the potential benefits of using VR in different STEM subjects. This inadequacy of the literature motivated this initial attempt to describe and propose a theoretical design framework that could assist educators, scholars, researchers, and policymakers to gather large data sets in order to analyse the potential of VR applications in combination with LA models.

Therein, in the context of this work, we filtered and analysed the elements that influence VR-support instruction the most and further combined them with LA practices. We believe that researchers and developers who are interested in these disciplines and envision a similar instruction-and-assessment system will find this work as the "go-to" source on the basis of which actual research and development efforts can be initiated.

The remainder of this manuscript is organised as follows: in Section 2 we synthesise the conclusions of different works related to the integration of VR and LA in STEM education and align them to the instructional design perspective. Section 3 entails the rationale and the purpose of the proposed theoretical design framework wherein, the design decisions are justified and the proposed developmental tools are analysed. Section 4 encompasses the main contribution and implications (conceptual, theoretical, and practical) made by this work. Section 5 discusses the potential of this work by blending conceptual and developmental elements of the proposed framework. Finally, Section 6 concludes with the most important limitations and provides directions for future research and development.

2. Background

2.1. Virtual Reality in STEM Education

Heim [12] argued over the potential of virtual reality (VR) by attributing its added value to three fundamental elements: interactivity, immersion, and information intensity. Despite the time that has passed since this claim was made, the experimental studies that have been performed ever since

not only confirmed its validity but, also, revealed the additional benefits that such "tools" can bring to the educational scenery [3,13]. Therein, in the context of this work, we adopt the definition that Gigante [14] coined, which defines VR as the computer-supported setting that enhances the real-world experience through the provision of multi-aesthetic stimuli (e.g., visual, audio, motion). Additionally, we expand the notion of this definition by providing a brief overview of the VR-supported (educational) settings that are available to date (e.g., room-scale VR such as CAVE, standalone-VR such as Oculus Rift, HTC Vive, and mobile-VR such as Samsung Gear VR, Google Cardboard).

The aforementioned setups promote different levels of embodiment (immersion) and offer variable opportunities for knowledge acquisition and construction (information intensity) whereas, the inclusion of haptic sensors, brings additional opportunities for interactivity and engagement. In a sense, this is what differentiates VR from other educational technology tools—i.e., the opportunity offered to learners to undertake both passive learning (e.g., observation of natural phenomena) and active learning activities (e.g., laboratory-related experiments) without spatiotemporal or time constraints. However, none of the above would have been possible without the rapid technological advancement of computing devices and the vast evolution of VR [15].

The integration of VR in different educational contexts is already playing a significant role as it has facilitated the application of contemporary instructional methods which enable learners to immerse themselves in the subject under investigation and thus, develop the cognitive strategies (e.g., problem-solving, critical thinking, creativity) that are essential in the 21st century [3,10]. Aligned to the notion of this claim, a common observation across the STEM education disciplines can be made regarding the nature of the programs and the respective interventions which follow (primarily) the principles of the experiential learning model. It, therefore, comes with no surprise why such tremendous efforts have been made to integrate immersive technologies to every education level which involves matters related to the STEM disciplines. This is also in line with the conclusions that [11] have drawn which attribute the successful integration of such technologies to the high degree of embodiment that users develop when interacting with the (digital) objects that have been customised following their personal needs and demands [9,11].

2.2. Instructional Design in Virtual Reality

Instructional design methods comprised strategies (e.g., instructor-guided, self-directed) and techniques (e.g., simulations, gamification) aimed at helping educators to contextualise the learning process and learners to link the concepts under investigation with their prior knowledge and experiences [16,17]. In other words, instructional design helps learners to understand what kind of information is provided within a specific context, how this information can be translated into knowledge acquisition, and how the constructed knowledge can be applied more effectively into practice [18,19]. The aforementioned processes are directly linked to the learning performance, which concerns the range of fluctuations in learners' knowledge development or behavior during the different stages of the intervention, and the learning outcomes (e.g., satisfaction, achievements, acquired knowledge/skills, competencies) that learners are expected to achieve at the end of the intervention [20].

The findings from the VR-supported educational activities are well-documented by a substantial body of literature as are the benefits that this technology brings to the learning process. Below, we provide a summary of the most important elements that influence the respective educational practices:

- Student-centered learning: Aligned to the principles of (social) constructivism and constructionism, the visually rich environment and the experimental nature of VR enable students to develop strong mental representations of the information sources through hands-on and collaborative activities [21,22].
- Self-directed learning: By exploiting the potential that the three-dimensional (3D) element offers, learners can investigate hypothetical and abstract concepts—which are difficult or even impossible to examine in the real-world—without spatial, time, and/or geographical boundaries [13,23,24].

- Self-regulated learning: Immersing learners in situations similar to the real-life context enables them to self-regulate the learning process following challenges and difficulties they are facing [25,26].

2.3. Learning Analytics

Educational practitioners and scholars have attempted to define LA from different perspectives. For instance, a portion of researchers [27–29] account them as an alternative method to gather student-generated data to provide personalised learning experiences. Others [30,31] set the focus on the patterns that can be developed from the students' learning behaviour to inform future instructional design decisions. Long and Siemens [32] have proposed a definition which considers and rounds up the aforementioned perspectives by suggesting that LA is a method to collect longitudinal educational data and a process that utilises the collected data to optimise learning and the environment in which it occurs. A significant number of researchers from different disciplines and fields (e.g., applied statistics, artificial intelligence, data Science) are working in collaboration to identify the diverse learning needs that students have and improve the present educational practices [32]. To achieve this goal, large sets of heterogeneous data—from different educational levels and sources—are collected, explored, and analysed using machine learning (ML) models. The outcomes of this process provide diverse, but equally useful, feedback to the educational stakeholders concerning learners' performance, the shortcomings of the utilised instructional approach, and the inadequacies of the course under investigation [33,34].

The added value of LA can be examined from different points of view. Below, we present the key-areas that LA influence, after considering the interests and the needs that the various stakeholders (e.g., learners, educators, instructional designers, policymakers) have:

- Learners: Alter the learning habits by identifying patterns and paths that can support the attainment of the learning objectives and ensure the achievement of the predefined goals.
- Educators: Improve the quality of teaching based on real-time and summative data that mirror learners' performance, involvement, and engagement throughout the time.
- Instructional designers: Increase the quality of instruction based on the analysis of the elements that have been utilised the most, the feedback from the students on the provided interventions, and the comments of the teachers.
- Policymakers: Develop clear and accurate awareness of current and future tendencies to inform the subsequent decisions and policymaking.

3. The Theoretical Framework Design

3.1. Rationale and Purpose

Accounting to the above, the desirable outcome of this work is to provide a theoretical framework that offers educators and instructional designers suggestions related to the data that can be collected from different VR-supported educational interventions and recommendations on the connections that may exist amongst them. To facilitate this goal, the main objectives of this work are split into three consecutive stages.

In the context of this manuscript, we elaborate on and discuss the perquisites that characterise the requirements of the *first stage* as presented below:

1. Development of a theoretical design framework which takes under consideration the research gaps that have been identified from the examination of the relevant literature.
2. Analysis of an instructional approach that can determine students, educators, and practitioners from different STEM fields while uncovering the most relevant variables related to this classification.
3. Identification of the most efficient ML models for the analysis of the error-related behaviors and the determination of the patterns that will improve the provided instruction.

In the *second stage*, we plan on using the proposed framework to design a functional prototype of a VR learning tool which can be applied in various iterations within the STEM education fields for evaluation purposes. Finally, in the *third stage*, it is expected that a complete training and assessment session is provided by utilising solely the recommendations of the LA measurements.

To achieve the objectives of the *first stage*, we propose the use of different approaches based on which the student models are shaped from the information that can be retrieved from the VR application and the companion learning management system (LMS). The proposed methodology that leads to the practical development of the proposed framework also comprises three parts, which are:

1. Use of statistical analysis models to classify students after collecting data from several VR-supported training sessions. The initial dataset includes information related to the course design, the learners' profile, and the interactions that the students had during the VR training task. For the construction of the final model it is expected that several statistical models are considered so as to increase the prediction accuracy and the reliability of the results.
2. Use of different feature importance analysis (FIA) methods to identify the most effective classifiers per task, the relevant variables, and their impact on determining students' success or failure for the task under consideration.
3. Use of an exploratory data analysis (EDA) tool to identify the relationships between the recorded errors. To this end, the clustered information is exported visually to develop different hypotheses related to the underlying reasons that drive these relations. For the visual representation, the LA guidelines that Baker and Yacef [35] have proposed can be applied.

3.2. Theoretical Framework Analysis

According to Hevner et al. [36] the design science research methodology is one of the most appropriate methods for the development of an information technology or information system artifact which, in this case, is the proposed theoretical framework. The main principle of this approach suggests the deconstruction of important problems on the grounds of which sound (technical) solutions can be developed. Therein, during the literature review that was conducted in the context of this work, we identified a set of issues that have not been yet addressed. These shortcomings, provide the foundation based on which we design the main requirements of this framework as presented below:

1. LA models are applied primarily to data that originate from LMS without considering alternative or supplementary tools.
2. The main sources for data collection consider the information that derives either from the technological or the pedagogical perspective of the tool/intervention but disregard partially or even completely the psychological one.
3. Relevant studies examine the correlations that may exist between a finite set of dependent variables (e.g., demographics, credits, grades) against non-classified parameters that are relevant to specific contexts and fields. This endangers the essence and the further evolution of LA as it prevents the collection and the sharing of large and homogenous data sets.
4. By cross-examining the latest (systematic) literature reviews, it became apparent that there is still a lack of a universally accepted comprehensive framework and/or system capable of providing the involved stakeholders with suggestions on the typology of the data that should be collected or recommendations on how to interpret such data to evaluate specific elements and improve their practices.

According to the above, the proposed framework (Figure 1) blends the aforementioned points by integrating the use of LA models for processing and cross-examination of the information related to:

(a) the technical affordances of the utilised tools;
(b) the instructional design choices that practitioners and educators make,
(c) the psychological elements that influence learning.

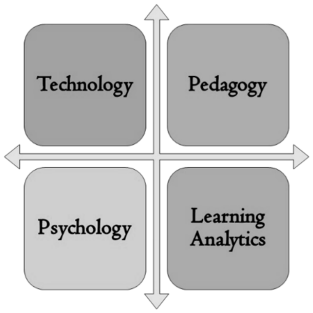

Figure 1. The four-dimensional framework for virtual reality (VR)-based learning analytics (LA).

3.3. Design Decisions

The information that can be collected from each category are illustrated in Figure 2 (abstract level) and elaborated upon further in the following sections.

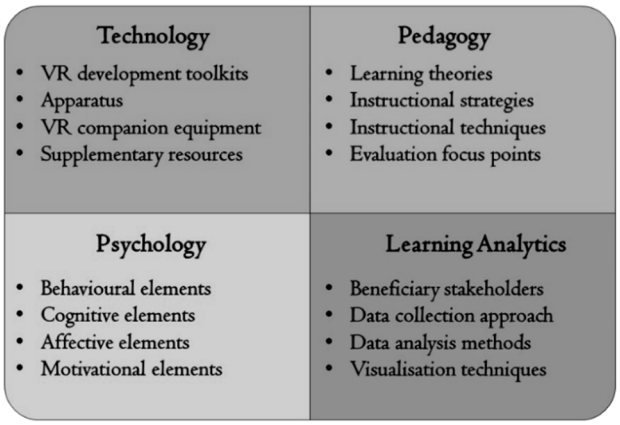

Figure 2. Classification parameters for each dimension.

In the first category (*technology*), we consider matters related to the design and the development of VR-supported interventions, such as:

- the software toolkits utilised for the development of the VR application (e.g., Unity, Maya, Net, Photoshop)
- the specifications of the hardware equipment utilised for the conduct of the interventions (e.g., smartphone, tablet, laptop, desktop PC, head-mounted display)
- the type of the VR approach (e.g., HMD-based, CAVE, 360° video) and the companion equipment (e.g., VR-enabled laboratory handbooks or discipline-related specialised equipment)
- the supplementary resources that may be required for the conduct of the intervention (e.g., multimedia resources, web-based educational platforms, 3D models)

In the second category (*pedagogy*), we contemplate the potential connection across the instructional decisions that practitioners make when designing educational activities [16], such as:

- the learning theories based on which the design of the intervention relies on (e.g., constructionism, cognitivism, (social) constructivism, embodied cognition),
- the instructional strategies (learning models) that gravitate the didactic essence of the respective theories (e.g., activity-based, experiential, collaborative, situated, problem-based, game-based, agent-based learning) and instructional techniques utilised for the conduct of the intervention (e.g., lecture, demonstration, seminar, tutorial, case study), and

- the evaluation focus points related to the effectiveness and efficiency of the application, the intervention, and the instructional approach (e.g., learners' performance, learning outcomes, learning gains).

In the third category (*psychology*), we consider the psychological elements that are connected to the pedagogical dimension and influence the learning process [37,38], such as:

- the behavioral elements (e.g., the impact/effect of reinforcement, user experience, visual attractiveness/intuitiveness),
- the cognitive elements (e.g., attention and memory span, problem-solving skills),
- the affective elements (e.g., interest, attachment, satisfaction, degree of arousal, social communication, nature of the activities),
- the motivational elements (e.g., self-belief, self-regulation, self-efficacy, self-goals, self-concept, self-esteem, situational interest)

In the fourth category (*learning analytics*), we consider the steps that are related to the data gathering and analysis process, such as:

- the information that can be collected from the different stakeholders (e.g., administrators, educators, students, assessment tools),
- the data collection approach which includes information related to the research method (e.g., experimental, quasi-experimental, non-experimental) and the research methods utilised (e.g., qualitative, quantitative, mixed),
- the data analysis approach which includes the use and combination of different methods (e.g., item response theory, cognitive diagnosis, evolutionary algorithms) and educational data mining models (e.g., decision tree, naïve Bayes, k-nearest neighbor), and
- the data visualisation models for the dissemination of the processed data (e.g., graphs/charts, scatterplots, sociograms, tag clouds, signal lights).

3.4. Overview of the Learning Analytics System

Educational data (Figure 3—Input) falls into three broad and usually overlapping categories: learning progression (Figure 3—Academic), learner intellectual competences (Figure 3—Cognitive), and learner behaviour (Figure 3—Psychology) whereas, external linked data—such as demographics or societal norms—can augment each of these. Aligned to the intended goal, in this section, we provide an overview of the functional requirements and specifications of the proposed system.

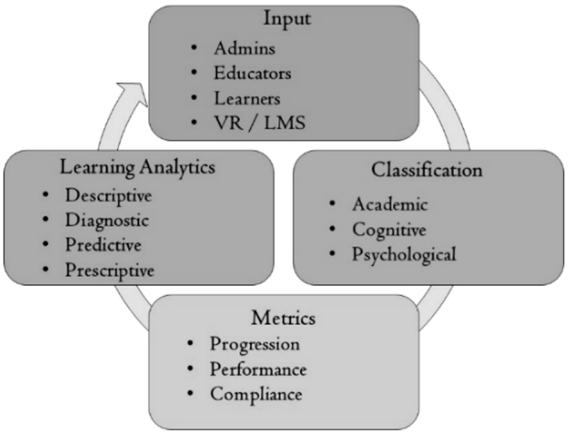

Figure 3. Overview of the LA system data processing approach.

However, prior to unfolding the specifics of the proposed system, it should be noted that the use of ML techniques benefits all the following stages as it is a prerequisite to filter the input data, analyse

the classification metrics, and interpret the results (learning analytics) in order to provide answers to the questions or concerns that educators and instructional designers usually have, such as:

- How to assess the skill cultivation between novice/expert students in VR STEM training scenarios?
- How to select the most appropriate instructional design elements to increase the effectiveness of the VR intervention, according to the difficulty of the topic and the learners' abilities?
- How to perform error diagnosis for VR-supported instructional settings in conjunction with LA?
- How to provide timely support to low-performing or additional opportunities for development to high-performing students?

In Table 1, we list some examples of data types (Figure 3—"Input"), that have been reported to be associated with LA practices and further adjust them to the concept of the proposed framework in accordance with their nature, collection method, and source of origin.

Table 1. Indicative examples of data collection types, methods, and sources.

Parameters	Method	Stakeholder
Gender, Age	Survey, Registry	Admins
Grades, Credits, Achievements, Enrolments, Dropouts, Attendance	Registry	Admins, Educators
Produced artifacts (Documents, Code, 3D models)	LMS, VR	Students
Log-in time/frequency, Time-on-task, Resources use, e-Assessment/Feedback	LMS, VR	Students, Designers
Activity setting (Blended, Distance, F2F, Individual/Collaborative)	LMS, VR	Educators, Designers
Usability (VR), User experience (VR)	Survey	Students
Attitude, Motivation	Survey	Students
Gaze, Gesture, Speech	Sensors	Students

Nevertheless, the actual integration of LA begins after identifying the patterns that support the development of deep understanding related to students' academic skills, cognitive competences, and psychological behaviour (Figure 3—"Classification"). For this reason, it is important to classify the gathered information in accordance with the area(s) (Figure 3—"Metrics") that are under investigation and/or in need of improvement (Table 2).

Table 2. Data classification.

Categories	Metrics
Academic Progression	Domain knowledge proficiency, Skills mastery, Knowledge retention, Learning strategies, Learning preferences, Learning styles, Performance, Achievements, Misconceptions, Cognition, Aptitude
Cognitive Performance	Efficiency, Evaluation, Achievement, Competence, Resource consuming, Elapsed time, Correctness, Deficiencies
Behaviour	Gambling, Guessing, Inquiring, Requesting Help, Willingness to collaborate, Time series of access and response, Persistence, Emotions

For instance, to measure matters related to the *academic dimension*, the primary data collection can include information related to students' management skills (e.g., use of resources), their prior knowledge with the scientific subject (STEM) and experience with the digital learning tools (e.g., VR, LMS) as well as their attitude towards the learning process (e.g., attendance, participation, interaction with the peers) and their learning competence (i.e., time to develop and integrate the acquired knowledge and skills). The primary data sources can include information originating from the students' interaction with the VR application and the LMS as well as self-reported cues related to their short- and long-term plans or goals (e.g., academic, personal, professional, monetary).

As regards the measurement of matters related to the *cognitive dimension*, self-reported data related to the ways that students regulate their efforts (e.g., strategies, tactics, habits) can be collected using validated instruments and further correlated with their learning outcomes (including the identification of misconceptions and knowledge gaps) using artificial intelligence techniques.

Finally, for the measurement of matters related to the *psychological dimension*, the focus is set on learners' behavioral patterns which are recorded from the onboard sensors of the devices that will be utilised for the conduct of the interventions (e.g., smartphones, tablets) and other wearables (e.g., HMDs). Such data include information related to learners' interactions (e.g., app use log, visual attention span, emotion recognition, textual communication records) and mobility patterns (e.g., frequency and duration of time spent at various locations).

The gathered data can be analysed under the aid of diverse statistical analysis methods and/or Machine Learning (ML) techniques (Figure 3—intermediate process between "Metrics" and "Learning Analytics"). However, before adopting such practices, it is essential to understand the features and benefits that each approach presents as well as the situations in which they can be applied (Table 3).

Table 3. Data interpretation.

Aim	Machine Learning models	References
Feedback to educators' and instructional designers' scenarios.	Decision Trees, Random Forest	[39,40]
Investigation of learners' behavior during and after the VR-supported intervention.	Naïve Bayes	[41]
Course adaptation and learning recommendations based on learners' behavior.	Decision Trees, Random Forest	[42,43]
Assessment of the VR-supported learning material and content.	Decision Trees, Random Forest, Naïve Bayes	[44,45]
Prediction of student's learning performance.	Decision Trees, Logistic Regression, Support Vector Machines	[46,47]

For the interpretation of the analysed data (Figure 3—"Learning Analytics"), we recommend the use of the model that Howson et al. [48] propose (Table 4).

Table 4. The analytics stages as described by Howson et al. [48].

Analytics	Description	Outcome
Descriptive	What happened?	Insights into historical patterns of behavior/performance.
Diagnostic	Why did it happen?	Evaluation of the examined data.
Predictive	What could happen in the future?	Identify trends / predict future behavior.
Prescriptive	How should we respond in the future?	Generate recommendations and make decisions based on algorithmic models

The output of these analyses (Figure 3—prerequisite for the "Learning Analytics" stage) is communicated to the interested stakeholders, who may not always be familiar with the dataset, via different mediums (LA dashboards) and techniques (*visualisations*). The use of graphic elements makes it easy to share insights and translate complex ideas into simple and easy-to-grasp concepts. However, while we recognise that LA tools provide rich and detailed information about the educational practices, they may also lead to information overload which may restrict educators' abilities to provide effective and adequate support to learners. Hence, it is essential to ensure that the receiver understands the purpose of the visualisations and its interpretation (Table 5).

Table 5. Data visualisation.

Evaluation	Visualisation Method
Collaboration	Mathematical graph, Statistical, Timeline, Interaction Matrix, Heatmap
Instructional Design	Mathematical graph, Statistical, Timeline, Word cloud, Interaction matrix, Circular graph, Bubble plot, Concept map, Glyph, Geomap
Learning Progress	Statistical, Circular graph, Heatmap, Radar
Retention	Statistical, Timeline, Word cloud, Glyph
Motivation	Statistical

4. Contribution and Implications

4.1. Conceptual Implications

The current study also contributes to the existing body of literature by providing a range of parameters that stream from the proposed theoretical framework and could improve teaching and learning practices. These are:

1. Orchestration of instruction by teachers and reflection on the utilised strategies from the originals available to them.
2. Evaluation methods to assess not only the students' performance but, also, that of teachers about the mode of operation and practices followed in both formal and informal contexts.
3. Provision of personalised suggestions and appropriate structures to support the implementation of similar scenarios in the future.
4. Development of deep understanding of the core elements that influence the educational process and adaptation of the educational resources based on needs and interests of the students.
5. Assessment of the course curriculum with particular focus on the parameters that affect the success and the effectiveness of the interventions in STEM training tasks.
6. Support from the administration for reshaping of the educational units and allocation of financial resources for the development of VR applications in formal teaching conditions.

4.2. Theoretical Implications

Several theoretical implications with regard to the development of a universal LA system tailored to the VR configuration setups are also provided. The following points are expected to guide the future developmental decisions but also provide instructions to those researchers, educators, and instructional designers who are willing to contribute towards this effort:

1. The decisions related to the data collection should be driven by the principles of the applied instructional design method. Hence, the involved stakeholders are encouraged to provide detailed information about the utilised instructional approaches, the educational subjects that were under investigation, and the analysis methods that have been followed for the examination of the correlations. In doing so, the repetition of the intervention to similar contexts facilitate and supports future research efforts to validate (collectively) the gathered information to develop well-grounded theoretical perspectives.
2. The potential of interactions should be examined holistically and not just unilaterally (i.e., both between the users and the VR system and among the users themselves). Under this consideration, we recommend cross-examination and correlation clustering of different pedagogical and psychological elements using ML models to aid the development of prototype profiles and allow the systematic mapping of the factors that influence students' outcomes and performance.
3. The classification of the gathered information should be done in accordance to the areas of interest of the different beneficiaries (e.g., administrators, instructional designers, teachers, students) and the outcomes should be disseminated following the data analytics maturity scale that Howson et al. [46] proposed (e.g., descriptive, diagnostic, predictive, and prescriptive analytics).

In doing so the involved stakeholders are able to determine the suitability and the effectiveness of the intervention and thus, perform any adjustments that may be required before designing or implementing new interventions.

4.3. Practical Implications

The inadequacy of the literature to provide recommendations with regard to the data types that can be collected from immersive technologies as well as the absence of a distributed system—capable of collecting, analyzing, and determining the appropriateness and the effectiveness of the VR-supported interventions in STEM education—motivated this initiative based on which we provide a set of practical implications which could help developers to better understand the functional requirements of such VR-supported LA systems:

1. VR technology produces huge amounts of data but not all of them are meaningful to the context of educational studies. For exemplification purposes we summarise the data sources that are pertinent to the aim of the proposed LA system followed by some indicative examples:
   - *visual* (e.g., eye motion tracking)
   - *auditory* (e.g., pitch/intensity of the environmental noise levels)
   - *haptic* (e.g., movement, rotation, force)
   - *network* (e.g., packet loss, time delay)
2. The essence of the educational VR applications relies on the provision of immediate feedback which offers answer-revision opportunities and leads to errorless learning. In the same vein, comprehensive implementation of a visual LA dashboard is expected to influence the learning dynamics (e.g., motivation, competitiveness, goal orientation) and impact positively learners' outcomes, achievements, and performance.

5. Discussion and Conclusions

In the context of the 21st century skills that individuals need to develop, more digitally oriented training programs and tools are needed to support and/or enhance trainees' digital competences and learning performance. At the same time, as STEM programs continue to gain ground globally, the need to improve and advance the existing instructional and assessment methods increases. To this end, student engagement across STEM fields is dependent on the appropriateness of the learning activities which, in turn, shape the capacity of the future professionals. Therefore, in order to guarantee the proficiency of the newly trained graduates, it is essential to integrate highly sophisticated and advanced instructional methods and evaluation techniques.

The potential of VR in STEM education has already attracted practitioners' interest by demonstrating its power to support the conduct of safe, interactive, and engaging learning experiences. At the same time, the LA domain is gaining more and more ground as it has immense potential to improve teaching and learning practices [24,28,29]. Typical examples include early warning and recommendation systems which provide personalised guidance, feedback and support to learners while enabling educators and instructors to better understand the needs and potential of their learners [49]. Other studies [50], focus on the analytics methods used to predict learning outcomes (e.g., completion, progression) and student retention [51]. Finally, a substantial body of the available literature is streamlined towards the educational data mining techniques and methods that are being used to achieve the aforementioned goals [52,53]. However, the attempts to integrate LA in the context of immersive technologies are limited and scarce.

Studies which blend pedagogy and cognitive psychology with LA could not be identified. Therein, in the present work, an effort to tackle this literature limitation was made on the basis of which we outlined the foundations of a four-dimensional theoretical framework which accounts the multifaceted layers that the learning process displays (technology, pedagogy, psychology) and combines them

with LA practices. In addition, we discussed the parameters and constructs that should be taken into account with particular emphasis on the impact that the different instructional strategies and methods have on the knowledge development process and the opportunities they bring to create personalised learning patterns [16].

By integrating LA, educators and instructors can also facilitate the assessment process. This is of particular importance now that teaching takes place in distant settings (e.g., remote/virtualised laboratories) and thus, timely feedback and feedforward is needed. For instance, a VR application dedicated to construction engineering includes both hands-on practices, using controllers and haptics, and observation-oriented actions using HMDs and standardised PC peripherals (e.g., geometrical calculations, 3D model editing, estimation of actual construction costs) in order to achieve the respective learning objectives. Any data collected during this process can be extracted via an embedded LA pipeline to a dedicated LA system for classification and interpretation using ML algorithms. For instance, supervised learning algorithms can be utilised to predict future events based on students' past behaviour and actions in the VR environment. On the other hand, *unsupervised learning* algorithms do not require historical information for the classification of the input data. In this case, the clusters are developed in accordance with the hidden patterns and connections that emerge during the training of the dataset under investigation (e.g., grouping of different VR exercises).

By highlighting these conceptual design elements, we envision that researchers, educators, and educational technology entrepreneurs will further consider these relations—when evaluating the potential of the utilised instructional VR approach so as to take full advantage of the data that can be collected from such tools and platforms and thus, support the students to reach their maximum potential. This statement also governs our future work recommendations thus, we advise VR developers and practitioners to make their primary data publicly available so as to support and promote such efforts for the mutual benefit of the respective communities. However, as LA entail multiple privacy management and ethical considerations we would like to highlight and remind that any data collection, interpretation, and dissemination practices should always follow the General Data Protection Regulation (GDPR) guidelines and the wider code of ethical research [54].

6. Limitations of the Study

As in any study, this one has its own limitations worth noting. First, due to the often-sparse definitions used to describe VR, we sought articles only from specific databases (Scopus, Web of Science, IEEE Xplore) with preference of selection over peer-reviewed international journals. Second, many of the originally identified articles were one-off studies with either too small samples or very context-dependent conclusions. As a result, when considering the features that could be integrated in the preliminary version of the proposed system, we opted for studies which were grounded to well-established theories and models and had reasonably large samples so as to compose a more realistic picture with regard to the needs that STEM education students have.

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Transversal Competences in Engineering Degrees: Integrating Content and Foreign Language Teaching

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Abstract: There has been a constant advance of the labour markets and permanent reorientation towards digital Industry 4.0. Yet, the environments for learning remain unchallenged when it comes to the provision of new professionals across the globe. Therefore, this has created a gap in transversal competences, which has compelled students of higher learning institutions to pursue them. The majority of higher learning institutions have emphasised transversal skills among learners and developed curriculums to accomplish these demands. The primary focus of the study was to attain integration and fusion of transversal skills into the development of specialised curriculum training for foreign language proficiency. The study applied mixed methodology techniques, which combined qualitative and quantitative methods in the study. To guarantee cohesion of the study, four research and monitoring techniques such as course dossiers, needs analysis, task-based activities and adapted competences scales were used. The outcome of the research shows findings provided by the piloting stage of the teaching experience and emphasises the need for student-based skill training.

Keywords: transversal competences; engineering students; higher education

1. Introduction

The 21st-century working environment is changing in a fast way. As a result, employers expect students to come out of their universities as people who are well versed with the changing trends [1]. Learners of higher institutions require specific training that ensures they develop social, ethical and professional accountability skills.

The universities have been entrusted with giving specialised skills that can be moved to any subject matter. These abilities are at the focal point of the accomplishment of students along with specialised and logical aptitudes. This situation makes transversal competences, a key region in numerous advanced education Industry 4.0 organisations over the world. They are now and then alluded to as flat or general abilities. The presentation of these competences is one of the progressions presented by the human asset board in numerous working environments to guarantee that an ideal contender for the activity is picked. Beginning and ceaseless cross-sector abilities preparation is fundamental to guarantee associations are proficient.

Likewise, several official documents have been issued in different countries to identify essential competences for engineering graduates, thus it is crucial to point out some of the most relevant ones [2]:

- In the European Community, the generic employability skills are: critical thinking, mastery of one's native language, team spirit, decision making, learning techniques, initiative, professionalism, civic-mindedness and sense of responsibility;

- In the UK, these are the Engineering Occupational Standards: plan and manage engineering products, produce engineering products, maintain engineering products, install engineering products, improve the quality and safety of engineering products, develop engineering competence and develop engineering products;
- In the USA, ABET (Engineers' Council for Professional Development) Engineering Criteria are: ability to communicate effectively, ability to function on multidisciplinary teams, ability to identify, formulate and solve engineering problems and ability to use techniques, skills and modern engineering tools necessary for engineering practice.

Based on the above discussion of competences in engineering training, the students attain two types of skills: acquiring a higher level of proficiency in entrepreneurial skills and transversal competencies that are intangible personal qualities. These skills are required in the work centres to strengthen the activities and results of the companies [3]. The following research questions were formulated for this study:

(i) What form of research methods and tools can address the enactment of transversal and linguistic competences in L2 training at the university level?
(ii) Is it possible to evaluate training results?
(iii) Is it feasible to personalise and account for the interests of students when developing a training course?

Thus, to address these research questions, comprehensive research on literature touching on transversal training was performed. The study applied scholarly articles, and a qualitative review and analysis were carried out to validate the stance on the significance of transversal skills in universities globally [4]. In this study, the notion of non-linguistic higher learning degrees enables deviation of technical to financial areas to extrapolate research findings. In addition, various geographical and political occurrences, as well as activities and social contexts across the globe, impact the issue.

Moreover, other critical elements to consider include the attitudes and expectations of students in the achievement of transversal competences, which should be developed by higher education schools [5]. Often the expectations of learners depend on what specific students desire to accomplish in the universities. Furthermore, it depends on the proposals that determine their training as well as their need to realize strong transversal competences. Moreover, some learners perceive the skills and competences development as a waste of time and immaterial in their areas of specialisation. Thus, the primary aim of the study was to change this perception through current research.

1.1. Universities and Transversal Competences

There has been a noteworthy change in Europe in the course of recent years. Twenty-nine nations signed the 1999 Bologna Declaration in Europe which empowered them to set up a zone for the European Higher Education Area. This was to fortify the coordination of the university and professional training into one body. The Bologna setting has not been restricted to Europe as different provinces have done likewise as the European nations [1]. Without a doubt, there has been a requirement for higher education institutions to figure out how to implement the manner in which they guarantee their students have certain abilities required in the active job market of Industry 4.0.

OECD (Organisation for Economic Co-operation and Development) [6] divided competences into technical (specific or necessary to fulfil a particular job) and core (delivery-related for achieving results, interpersonal for building relationships and strategic for future planning) branches. Additionally, the OECD framework provides key behavioural indicators of five different levels of performance associated with the workplace. It is therefore essential to combine both cognitive and non-cognitive aspects of being able to accomplish a given task or job successfully.

Subsequently, both governments and universities have been giving a valiant effort to provide cooperation between engineering studies and competences needed by organisations. The competence idea has been first established as a skill that plays critical roles in ensuring people can perform their duties at full capacity. An individual should be able to do the task at hand [7]. Three concepts can be

used in determining competence. The behavioural approach is one of these concepts [8]. The method has been used in the United States for a long time because it emphasises professional behaviours. In this perspective, competence is achieved through training and development. This feature deals with the behaviour of observation, assessment and improvement of personal traits such as excellent interpersonal skills that allow a high-quality performance of professionals. The second approach is a generic one that tries to explain the difference in a variety of settings. Finally, the cognitive focus identifies standard abilities that define the variations in behaviour patterns among professionals. Competence is the ability to perform a job according to the expected standard [9]. This definition adds more to the importance of the inclusion of transversal competences in non-language degrees to ensure that graduates can deliver the expected outcomes in the job market.

The concept of transversal competence takes a holistic approach since there is a link between power and performance as long as power refers to the successful fulfilment of challenges and requirements; capability assumes a different brain ability and refers to the use of various skills in deciding the next step. The competences enable focus on the acquisition of capacities and not just the accumulation of knowledge. The acquisition of knowledge was the strategy used for the transmission prevalent in the educational centres [10]. This definition is one of the common ones used for the subject [11]. There are two types of competences from the definitions: general and specific competences. General competences can be applied to all kinds of jobs and are the basis of attaining all other skills while specific competences are only used in the environment in which they are developed.

Therefore, transversal competence is essential in institutions of higher learning for the benefit of the students. Its acquisition is influenced by different variables (e.g., number of students and activities, among others). These variables can accelerate knowledge acquisition in students, therefore their analysis is necessary [12]. General or oblique skills are acquired in the learning process as an educational aspect. The position is essential because it helps all the parties involved to benefit from the knowledge offered by a higher institution. One of the core roles of education is the instilling of transversal or general competence that enables future employees to relate well with each other in the workplace. This allows them to handle their future roles well. The use of different methodologies and multi-disciplinary approach is key in learning transversal competence, improving the educational process [13]. With the objective of a correct interpretation of the term "transversal competence", we underscore that transversal competence is the ability of the student to communicate, manage, relate, create and recognize [14].

The chosen literature has played a vital role in its proposals on what transversal competences entail from hard (data and administrative skills) to soft skills (behavioural skills). The way people consider the importance of soft skills vary depending on whether a person has a job or not, enabling the inclusion of people in special situations in the labour market [15]. Employers and students that have a job are believed to be interested in giving soft competences priority while those that do not have a job put more emphasis on hard competences [16]. A student should have soft skills if they intend to achieve in their jobs. To generate organisational excellence, the students have to combine both hard and soft skills. There is also an existing gap in the education sector where students have a different expectation from what the employers are willing to accept. Higher learning education cannot fulfil the desired competence that students want sometimes. There is, however, a change in the education and industry system as both sides look for ways to address the challenge.

1.2. The Relevance of Promoting and Teaching Transversal Competences in Higher Learning

The higher education and the way the message is delivered plays a key role in determining the importance of transversal competence and the students' use in the new challenges of the labour market, which change rapidly [17]. New education strategies show the need to evolve the educational systems as well as the teaching styles in order to increase the level of the students' skills [18]. Both national and international bodies that accredit institutions integrate with their assessment the competences learned by students in the course of their study in institutions as students and the future as professionals. The institution of higher education should also be accredited to ensure that students get the best from their

teachers. As a result, they will offer the best to the employers [11,19]. The students should play a key role in ensuring the relevant authority accredits their teachers and the institution that they attend. Failure to do the due diligence will lead to loss of time and money.

There are times that government agencies will not be able to regulate all institutions because of financial constraints. However, the support policies are essential in the evolution of institutions of higher learning from concentrating on the result of centres to competence-based teaching [20]. The value of this method is critical to education because it allows one to redefine the goals of education. It also helps in paying particular attention to the needs of the learning process. As a teacher, it is essential that one can introduce adaptive strategies in learning. It is also vital that there is a designed dynamic environment that would encourage interaction and corporation.

The basic user, independent user and proficient user are the three categories of reference that the European Council has identified as levels of language proficiency [21]. These broad categories can further be subdivided into the needs of the local context. It marks a turning point as the Common European Framework of Reference for Languages (CEFR) and CEFR Companion Volume can be adapted for various contexts and applied in multiple languages [22]. Self-learning is critical in the education system because of its freedom in choosing the time to study and which materials to use in the study process [8]. This is fostered among students in institutions of higher education. It creates the desire to add to one's level of knowledge to be able to predict a phenomenon as well as to describe a particular event. Teaching, therefore, has to be grounded on practical more than theory work that approaches the actual profession to give students real work experience. In some instances, actual practice is essential to install competence. Task- or work-based projects, project work, case studies and problem-based projects are some of the examples that can be used to show how the learning process can be achieved when there is a mixture of technical and soft skills [23]. The approach is critical in ensuring students can get real-life experiences. For this process to be successful, students must be actively involved in a self-regulated process. An excellent example is the adoption of the self (teacher or peer) assessment criteria scale chosen for this study as a part of the learning outcome measurement.

2. Material and Methods

Transversal competence deals with the ability of a student to communicate, manage, relate, create and recognise. In order to tackle the issue of its implementation in engineering-degree-specialised content and second language (L2) learning, the following methods and research tools were used in this study (Figure 1).

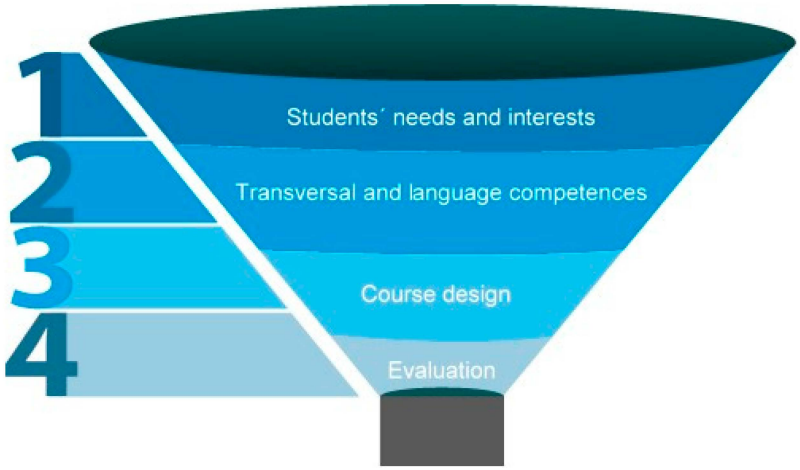

Figure 1. Experimental design structure.

2.1. Student Needs Survey

As demonstrated by the hard and soft transversal competences required in the university and work context, it is necessary to be a qualified specialist and to have a correct command of professional expertise

and ability to effectively communicate it to others. Additionally, for this challenge, university students have to acquire L2 (English language) skills. Thus, non-linguistic education requires a strong focus on communicative and transversal competences embedded in curricular programming and teaching materials of specialised language subjects. The tool selected for detecting students' points of view was a needs analysis that collected learners' background information on English training and special vocabulary preferences. In 2018, 76 engineering students of the Universitat Politècnica de València took part in this survey providing professors with their opinions and suggestions that will be described later in the Results section.

2.2. Teaching and Measuring Transversal and Language Competences

As mentioned before, one of the key priorities of higher education institutions is the type of training that helps achieve transversal competence. Conversely, professors cannot utilise them to handle specific language skills because of the missing linguistic parts and choose to use a B2-level scale. For the current study, the researchers needed to design a particular scale for estimating transversal competence accomplishment inside a specific ESL (English as a Second Language) preparation setting.

For this reason, professors proposed an adjusted scale dependent on the core abilities improvement provided by the Transversal Capabilities Project (Universitat Politècnica de València) and language skills characterized in the refreshed CERF (Common European Framework of Reference) [11]. Toward the finish of every unit, professors would ask their students to self-evaluate their development regarding both competences as indicated by a standard 5-point Likert rating scale.

On the one hand, to address transversal competences, professors apply the Transversal Competences Project developed by the Universitat Politècnica de València and containing the following transversal competences (TCs): TC-01 comprehension and integration, TC-02 application and practical thinking, TC-03 analysis and problem solving, TC-04 innovation, creativity and entrepreneurship, TC-05 design and projects, TC-06 team work and leadership, TC-07 ethical, environmental and professional responsibility, TC-08 effective communication, TC-09 critical thinking, TC-10 contemporary problems knowledge, TC-11 lifelong learning, TC-12 planning and time management and TC-13 specific instrument competence.

On the other hand, language components promoted by the updated Common European Framework of Reference for Language [22] will play an active role in emphasising the B2 level of English through seven language competences (LCs): LC-01 listening, LC-02 speaking, LC-03 reading, LC-04 writing, LC-05 mediation, LC-06 pluricultural and plurilingual competence and LC-07 online training competence.

2.3. Course Design

Professors should recognise that students' motivation is a basic connection in the learning cycle. Because of its customised approach, educators can structure a teaching/learning process planned for accomplishing curricular objectives. In particular, the international language goal centres around level B2 [22,23] and involves the right authority of the four abilities (speaking, listening, reading and writing).

Nevertheless, at the lexical level, the course design needs investigation, the results of which will give us strong support on the topical decision for the course dossier. The dossier takes a quick look at the undergraduates' vision with respect to subjects or topics utilised to strengthen competences. The dossier material will be incorporated from ten units dependent on a specialised technical segment confirmed by students, a wide scope of learning activities. Every unit will advance the application and improvement of transversal competences through a dynamic L2 situation just as it will empower reflection on the information and aptitudes gained.

This educational device is proposed in accordance with the learning cycle based on assignments and interactions aligned with the curricular systems by [24–28]. These directions will permit certain ideas to be taken into consideration at a more prominent level of variation applied to the learning goals and competences.

3. Results and Discussion

3.1. Needs Questionnaire

The research placed students at the core of the learning process based on the Bologna Process priorities. The study focused on both linguistic contextual and technical thematic student preferences. The used sample was a group of students who studied for a Bachelor's Degree in Industrial Engineering. These students were between 20 and 23 years old. The group consisted of 76 students from the academic year of 2017-2018. Therefore, all students developed the study this year and its preview studies were similar. They took part in a needs survey to provide precise data through the Google Drive format survey.

In the needs questionnaire, the researchers explored future engineers´ linguistic background, opinions and motivation relating to ten curricular topics. The goal was to understand students' concerns better and update the L2 training design to be applied in upcoming course editions. Due to the student-centred approach placed at the heart of our methodology, the objective of using a survey in this study was to investigate three specific domains: (1) language learning, (2) potential L2 use preferences and (3) recommendations of Spanish engineering undergraduates. Therefore, the questionnaire began with the outlook of the key foreign language background as an indicator of the students' preliminary preparation. Next, we inquired about the perspective use of English for professional purposes, and finally, the recommendations offered by our respondents completed the process.

The results of the study are indicated below:

(1) Language learning. Based on the responses obtained, 81.6 percent of the Engineering Degree began studying English in elementary school. In addition, 42.1 percent of study participants reported having acquired the official certificate of level A2 of English, while 7.9 percent possessed a formal degree of level B1. Moreover, 7.9 percent of the participants had level B2 degrees, and 42.1 percent lacked any form of official certification. When a question regarding their experience of learning English was addressed to participants, the outcomes obtained related to the almost equal spread of courses, with 22.4 percent agreeing to having experience with general English B1. Furthermore, 25 percent admitted to having experience with technical English B1, 28.9 percent with general English B2 and 23.7 percent reported a lack of previous experiences.

(2) Potential L2 use and preferences. The prospective use of English provides clear proof of the study participants acknowledging the significance of L2 to accomplish professional objectives. Of the study participants, 78.9 percent reported the application of English in their future areas of employment as the most probable scenario. At the same time, 13.2 percent of study participants indicated travel and free time as the likely reasons. In addition, 6.6 percent of study participants reported the university educational settings as the main reason, while 1.3 percent stated friends and family. From the survey, 32.9 percent of students desired to work within the field of process management and maintenance. Moreover, 28.9 percent preferred to work in research and development fields, 27.8 percent in project management and consulting, while 10.5 percent preferred to work in technical sales assistance and customer service.

Based on work expectations, 47.4 percent of university students with degrees reported future requirements of specific English vocabulary, 39.5 percent indicated general English vocabulary, 7.9 percent general English grammar, while 5.3 percent indicated specific grammar. The study participants suggested that the most critical linguistic competence required for their professional future was oral expression at L2 at 81.6 percent, 9.2 percent for verbal expression, 5.3 percent for written expression and 3.9 percent for reading comprehension. Therefore, the information collected from the study yielded very substantive findings.

(3) Proposals and recommendations. The needs analysis survey incorporates several open-ended questions, such as:

(i) What is the best textbook for each study participant? Respondents provided the following answers: Gold First, Communicating Across Cultures, Face-To-Face, English Grammar In Use, Objective First, Cambridge English B2 Level, My Grammar Lab and speaking skills books.

(ii) What other subjects can be included in the course design? Respondents provided the following answers: cinema and history, art, science, novel technologies, team work, marketing techniques, communication abilities, negotiation and business abilities. The findings obtained assisted in acquiring features of previous L2 understanding students, authenticating likely educational subjects and proposals concerning L2 training experience for students.

3.2. Transversal and Language Competences

As discussed earlier, the study incorporated an adapted evaluation scale that fortifies the process of knowledge acquisition and guarantees competence is established. Moreover, Tables 1 and 2 show the developed rubrics, which propose a user-friendly model of descriptors, competences and Likert scale marking for self-assessment used by educators and students.

Table 1. Transversal competences and proposed descriptors.

	Competence	Markers/ Descriptors	Likert Scale (1-5)
Transversal Competences, 65%	TC-01 Comprehension and integration	I can demonstrate the understanding and integration of knowledge both of one's own specialisation and in other broader contexts.	
	TC-02 Application and practical thinking	Apply the theoretical knowledge and establish the process to follow to achieve certain objectives, carry out experiments and analyse and interpret data to draw conclusions.	
	TC-03 Analysis and problem solving	Analyse and solve problems effectively, identifying and defining the significant elements that constitute them.	
	TC-04 Innovation, creativity and entrepreneurship	Innovate to respond satisfactorily and in an original way to personal, organisational and social needs and demands with an entrepreneurial attitude.	
	TC-05 Design and projects	Design, direct and evaluate an idea effectively until it is finalised in a project.	
	TC-06 Team work and leadership	Work and lead teams effectively to achieve common goals, contributing to the personal and professional development of them.	
	TC-07 Ethical, environmental and professional responsibility	Act with ethical, environmental and professional responsibility before oneself and others.	
	TC-08 Effective communication	Communicate effectively, both orally and in writing, appropriately using the necessary resources and adapting to the characteristics of the situation and the audience.	
	TC-09 Critical thinking	Develop critical thinking being interested in the foundations on which the ideas, actions and judgments, both one's own and those of others, are based.	
	TC-10 Contemporary problems knowledge	Identify and interpret contemporary problems in their field of specialisation, as well as in other fields of knowledge, paying special attention to aspects related to sustainability.	
	TC-11 Lifelong learning	Use learning in a strategic, autonomous and flexible way, throughout life, according to the objective pursued.	
	TC-12 Planning and time management	Properly plan the time available and schedule the activities necessary to achieve the objectives, both academic and professional.	
	TC-13 Specific instrument competence	Use the techniques, skills and updated tools necessary for the practice of the profession.	

Table 2. Language competences and proposed descriptors.

	Competence	Markers/Descriptors	Likert Scale (1-5)
Language/linguistic competences, 35%	LC-01 Listening, B2	Can understand the main ideas of propositionally and linguistically complex speech. Can follow extended speech and complex lines of argument.	
	LC-02 Speaking, B2	Can give clear, systematically developed descriptions and presentations, with appropriate highlighting of significant points and relevant supporting detail. Can give clear, detailed descriptions and presentations on a wide range of subjects. Can communicate detailed information reliably. Can give a clear, detailed description of how to carry out a procedure. Can interact with a degree of fluency and spontaneity.	
	LC-03 Reading, B2	Can read with a large degree of independence. Can scan quickly through long and complex texts, locating relevant details. Can quickly identify the content and relevance of news items, articles and reports on a wide range of professional topics, deciding whether closer study is worthwhile.	
	LC-04 Writing	Can write clear, detailed texts on a variety of subjects related to his/her field of interest, synthesising and evaluating information and arguments from a number of sources.	
	LC-05 Mediation, B2	Can convey detailed information and arguments reliably, e.g. the significant point(s) contained in complex but well-structured, texts within my fields of professional, academic and personal interest. Can encourage participation and pose questions that invite reactions from other group members' perspectives or ask people to expand on their thinking and clarify their opinions.	
	LC-06 Pluricultural and plurilingual competence, B2	**Can describe and evaluate the viewpoints and practices of his/her own and other social groups, showing awareness of the implicit values on which judgments and prejudices are frequently based. Can alternate between languages in his/her plurilingual repertoire in order to communicate specialised information and issues on a subject in his field of interest to different interlocutors.	
	LC-07 Online training competence, B2	Can participate actively in an online discussion. Can engage in online exchanges between several participants. Can recognise misunderstandings and disagreements that arise in an online interaction and can deal with them.	

3.3. Course Design

The course design addressed the primary areas of English grammar and emphasised various factors that students require to improve in reading, listening and writing competences so that they can confidently communicate. The created dossier comprises ten units that are founded on the most recent subject areas to engage students to learn the language based on the requirements of the B2 level, transversal competences and future professional needs (Table 3):

Table 3. Course topics and key contents based on [29].

Unit 1. The world around us	Review on different kinds of energy (100 words). Learner notes, self-assessment
Unit 2. Health technology	Informal email about healthy lifestyle tips (100 words). Learner notes, self-assessment
Unit 3. On a business trip	Travelling as a student/ professional (100 words). Learner notes, self-assessment
Unit 4. Academic issues	Academic CV (100-150 words). Learner notes, self-assessment
Unit 5. Buildings and facilities	Formal e-mail writing, facility description (100-150 words). Learner notes, self-assessment
Unit 6. Workplace	Job interview questions and answers (100-150 words). Learner notes, self-assessment
Unit 7. Communication	Customer service e-mails (150-200 words). Learner notes, self-assessment
Unit 8. Projects, creativity and innovations	Innovation report or description (150-200 words). Learner notes, self-assessment
Unit 9. Business and industry	Career goal statement (150-200 words). Learner notes, self-assessment
Unit 10. Rules and regulations	Special rules and regulations overview (150-200 words). Learner notes, self-assessment

When associating the teaching of L2 communicative skills with the transverse abilities, the pot of origin in the ten educational units was designed to suit the educational requirements of future professionals. Similarly, every unit suggests coherent communicative-linguistic methods of level B2 and links contents to the list of transversal competences selected for the existing project. Through this, the study accounts for the dossier created so that all L2 English professors can have various pre-developed thematic activities tightly-linked with skills development. In addition, the format of the record will enable the inclusion of academic tasks founded on the cross-curricular projects and pursue new ventures of collaboration with educator-professionals in specialised topics.

3.4. Evaluation and Discussion

Competences refer to applying knowledge and skills that make people do their work fruitfully while applying the required capabilities and roles [30]. Competence in education is determined by the way an education system inflicts both social and professional values. This paper evaluates a unit piloting of a textbook and its relation to the promotion of competences by analysing two groups of students.

Before launching the course as a printed and edited proposal, professors piloted it with a group of Scandinavian students first. Given the confidentiality restrictions, the exact name of the higher education institution cannot be mentioned here. Thus, the non-linguistic university students were provided with the unit 3 part of the course "On a business trip". The main purpose of the experiment was to check whether the tasks designed were useful in terms of communicative and transversal competences. As professors included an innovative topic selection, the academic staff were also interested in the motivational aspects of the piloting. The upcoming part offers a brief overview of the opinions and suggestions collected during the process by one of the study authors.

The Scandinavian country was first piloted with the unit 3 part of the English course "On a business trip". The country rolled out the English language course and registered some marked progress in communication grammar and language skills. The country has quite a different profile when it comes to English language learning. The study of the country's education system enabled the professors to identify some marked differences in communication and language skills between the

Scandinavian and Spanish countries. Students in the Scandinavian country had adopted the course B1 course on communication skills and therefore had a much higher level of English [30]. Spanish education system lacks a course in grammar; therefore, choosing the country as a study country enabled the professors to identify the expected outcomes in pursuit of the program's communication skill adoption. It also enabled the professors to identify the traits separating English language incorporation in learning and vice versa. Both the Scandinavian and Spanish countries are in Europe, where the Common European Framework for languages regulates the language level in the entire territory of Europe. However, the Scandinavian students were from an applied sciences university, while the Spanish ones were from a polytechnic university [31].

In the focus group phase of the study (13 Scandinavian students) we had a unique opportunity of using course materials in a different cultural environment. Therefore, the invited lecturer focused the lesson on communicative tasks and grammar-based activities. The students worked in small groups of 3-4 persons each to practise such transversal competences as TC-03 analysis and problem solving, TC-06 team work and leadership, TC-08 effective communication and TC-09 critical thinking. The upcoming part offers a brief overview of the opinions and suggestions collected during the process by one of the study authors.

Communication in grammar always focuses on accuracy; proficiency is more important during the training period. Training in communication is important as it allows trainees to practise the target grammar under real-life conditions to solve both professional and social issues [31]. The training majorly focuses on verbal activities, but the writing process is also essential and reasonable in communication via grammar.

The outcome of adopting the B1-B2 programme on the students' communication skills in Spain is encouraging since it evoked communication competencies (Bostrom, 1984). It is therefore advisable to develop grammar skills for the nourishment of grammar skills among students. Rapid internationalization of adoption of Learning of Communication Skills is healthy in enacting mutual knowledge, diverse communication and boosting communication in workplaces. Furthermore, racial, linguistic and cultural diversity will increase, and as a result, there will be a greater need for cultural tolerance [31]. Consequently, the students also said that success in future employment requires deep knowledge about working with people of different cultures because the future requires qualification and future activities vary.

In conclusion, the discussions showed that internationalization should be part of the business of the future. It requires the ability and willingness to think and act globally. In addition to this knowledge, transversal competencies, skills of different market regions and their knowledge of international trade, culture and languages are required. It is also suitable for prospective staff to be comfortable and easily trained for multi-structured, new jobs. According to the research they made, it is easily visible that the demand for these specifications has increased remarkably as an outcome of current corporate scandals. For the preparation of students for the future, education requires developing problem-solving skills and creativity in a work-life scenario based on real-life opportunities. At work, problems are often controversial without an adequate resolution and require skills and know-how from many areas, proper grammar not excluded.

The picture that emerges from the study above is one of new university teaching and learning practices being reshaped as competent background implies the constant nexus to contemporary workplace demands. Higher education institutions attach great importance to the outreach activities of transversal competences and insist on knowledge acceleration by using the type of training as shown by [10,32,33].

Nevertheless, this progress is not fully related to the integration of content and foreign language teaching where many researchers support English-medium policies [34], content-based L2 teaching for developing thinking skills [35] or multilingual/plurilingual university strategies [36]. Additionally, the study performed by [37] stands apart in this list whilst it reaffirms the role of content language

integrated learning as a driver for improved graduate employability; the position is close to our views in this respect.

4. Conclusions

The study on the significance of transversal and language competences in universities shows the type of capacities that institutions of higher learning need to pursue. Regarding limitation, the research focuses on critical evaluation of the appropriateness of transverse abilities in non-language degrees to promote the employability status of students and the provision of the desired outcomes. The study hopes that individuals who will use the research will be able to acquire an insight into the significance of English subjects both within and outside classroom environments.

The outcomes of this research demonstrate that it placed significance on the establishment of a dependable method of study. In addition, several tools of research for tackling thematic interests for technical students and linking the students to their curricular objectives were addressed. This assists in adopting innovative competence-based initiatives. Therefore, student participants were able to answer the research questions (RQs) in the following format:

RQ (i)The combined method that made it possible to ensure the cohesion of the study based on quantitative and qualitative techniques was showcased by the survey requirements, course design, evaluation scale and piloting.

RQ (ii) Adapted skill scales combining transversal and language competences can be employed to evaluate learning outcomes.

RQ (iii) The needs of students were identified by the needs analysis, which forms part of the core elements of motivation towards capacity training. Piloting findings showed promising results, although slight adjustments had to be carried out.

The primary finding of the study is a course design proposal that makes it possible to integrate the needed factors to complete the learning process via the pursuit of transversal capacities. The most outstanding practical influence of this research is that the suggested design enables for a structural and coherent establishment of transversal and language competences and their measurements via a rubric. Therefore, the study assists students in acquiring a vigorous vision of their learning activities. Specifically, transversal capacities implementation is often presented in the framework of a subject, yet there are no precise academic resources that gradually embody the competences and systematically via cross-curricular skills. This study cannot be extended in this course due to the pandemic situation (COVID-19), but the researches will try to increase the number of students next year.

Although L2 transversal learning can be problematic, it can also be exciting if it is positively carried out. English language transversal learning incorporates the engagement of various individuals such as educators, graduates and employers to ensure the learners can prosper in their academic ventures.

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Article

Measuring the Degree of Academic Satisfaction: The Case of a Brazilian National Institute

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Abstract: The Brazilian National Institutes are strategic elements for the growth and development of Brazilian society since they have the purpose of meeting social and economic demands. However, for this purpose to be materialized, it is essential to develop strategies and mechanisms that consider the current educational context, marked in large part by the transformation of education into a product and the increased awareness of students who expect to have their own needs met in terms of achievement and satisfaction. Based on this premise, this research aims to present an indicator for measuring student satisfaction of students from the Federal Institute of Education, Science and Technology of Piauí-Campus Oeiras (FIEPI-Campus Oeiras), in order to provide evidence of how satisfaction has presented itself in relation to the different educational profiles present in the institution. The study was conducted with a sample of 290 students from FIEPI-Campus Oeiras. The instrument used for data collection was a questionnaire structured in two sections, in which the first was intended to obtain information to characterize the sample and the second section, composed of 14 items, aimed at measuring students' satisfaction with the institution. Descriptive, exploratory, and inferential statistical techniques were used for the data treatment and for the validation of the results. The results indicate that the students are slightly satisfied with the institution and that the average satisfaction is different in relation to the courses and technological axes.

Keywords: satisfaction; educational management; average satisfaction index; IFPI; Brazil

1. Introduction

Among the purposes and characteristics of the Federal Institutes of Education, Science and Technology (FIEPI), established by [1], is the provision of professional and technological education, at all levels and modalities, forming and qualifying citizens in view of the basic premise for professional performance in the various sectors of the economy, with an emphasis on local, regional, and national socioeconomic development as an alternative when facing social exclusion through the insertion of men and women in the labor market [1].

Accordingly, the Federal Institutes are strategic elements for the growth and development of Brazilian society in terms of two complementary and inseparable aspects. On the one hand, they meet social demands, with the formation and elevation of the population's education levels, providing better conditions of employability and the consequent insertion in the labor market. On the other hand, they meet the demand for productive capital, contributing to the process of modernization

and development of the country, by providing qualified labor that leads to substantial increases in productivity and, consequently, higher profit rates [2].

However, for the professional and technological education offered by the Federal Institutes to meet their purposes, it is essential to develop strategies and mechanisms that consider the current educational context, characterized in large part by the transformation of education into a product and by an increase in students' awareness, who expect not only a diploma but that educational institutions consider and meet their needs (at a time when having a diploma will become the norm in modern societies, thus students having to distinguish themselves by the quality of knowledge acquired, in the teaching and learning process) in terms of satisfaction and fulfillment [3,4].

Research carried out in other countries, such as the United Kingdom, Romania, Portugal, and China, has shown that academic satisfaction presents itself as a multifaceted construct and with determining characteristics particular to each country, whose emphasis has been on analyzing the influence of several variables, such as the quality of the materials used, the motivation of the teaching support team, tangible aspects of the institution, face-to-face activities, learning designs and tangentially, the influence of motivation and cognitive aspects of students on academic performance, which ultimately can be mediated by academic satisfaction [5–10].

Given this context and given the strategic importance of the Federal Institutes, the present investigation has as its main objective to present an indicator for measuring student satisfaction of students at the Federal Institute of Education, Science and Technology of Piauí-Campus Oeiras (FIEPI-Campus Oeiras), in order to provide evidence as to how it presents itself in relation to the different educational profiles present in the institution.

The justification for this is based on the fact that the understanding of student satisfaction becomes important as it is an educational management tool capable of evaluating and monitoring student satisfaction by educational institutions, further constituting an indicator that reflects how satisfaction is presented, serving as a parameter for correcting failures and implementing potential improvements that increase student satisfaction and achievement, thereby increasing their chances of staying and succeeding in institutions.

In addition to this introduction, the article is structured in six other sections. The following section is about the main concepts that guide satisfaction in general and in the student context, followed by a section on the study's objectives and research hypotheses; after this, the method used for the development of this research is described. Additionally, the results arrived at are presented, constituting the core of the present investigation, then, the results are discussed, and, last but not least, the article ends with a conclusion and the references used are set forth.

2. Literature Review

In general, all organizations today are concerned with satisfying their users, whether they are considered as customers or consumers, and whatever their age, although it is mostly millennials currently attending higher education [11]. Consumer satisfaction is at the core of modern marketing, in both a theoretical and practical way, based on the premise that organizations need to know the needs of their consumers in order to survive and thrive [12].

Within this context, the concept of consumer satisfaction provides an understanding of how consumers develop positive or negative affect for products, services, and brands, and how this is reflected in current buying behavior, constituting a central theoretical issue. From a practical point of view, consumer satisfaction is one of the main objectives to be achieved, since without understanding satisfaction, it is unlikely that it will be possible to establish loyalty with any brand [13].

In the literature on the topic, there is no clear and widely accepted consensus on what satisfaction is, which has limited the appropriate development of measures and the comparison of results between studies. However, consumer satisfaction can be related to an affective response that varies in intensity, with a focus on the choice of a product, its purchase, and consumption and also with a specific

time when satisfaction occurs, which can vary from one situation to another, but which is generally limited [14].

On the other hand, consumer satisfaction can also be defined according to the emphasis given to the term satisfaction, so that it can be understood as a result of an evaluation on some attribute, or as a deeper process that involves an experience of consumption in its entirety [15]. This fact is corroborated by some authors [16–19] who present satisfaction as an attitude of judgment, an affective response and/or a general assessment centered on a comparison between the expected and actual results of a given product or service.

The growth in demand, the increase of vacancies for students in higher education, and the fact that, in recent years, education, in general, has come to be understood as a product, have given rise to a greater concern with the quality of services provided by the institutions of higher education. Teaching in higher education [3,20] is now often also making use of technological tools to provide a better service [21] as in other domains in the digital era.

In addition, in the current educational scenario, students expect institutions to be concerned with satisfying their needs, using active methods for the formation of critical and complete professionals who are differentiated from others when entering the labor market [4,22], that in the specific case of Federal Institutes of Education, Science, and Technology, that have similar organizational and pedagogical structures oriented for the development of technical and technological solutions to attend social demands and regional particularities [1], become more expressive.

In this context, for institutions to attract and retain students, it is necessary to increase their satisfaction while reducing their dissatisfaction with the institution, offering educational services that, in fact, contribute to academic life, and regularly assess the students' satisfaction in order to identify strengths and weaknesses that can support the adaptation of the services provided, in order to increase student satisfaction [23,24], which in some manner has been done by Federal Institutes of Education, Science, and Technology, where there is evidence that students, in general, are satisfied with this kind of institutions [25,26].

Student satisfaction is related to students' experiences during the course, constituting an important influence factor in their permanence and in creating a positive image of the institution. Satisfaction assessment provides teachers with valuable information and feedback that encourages retrospective reflection to assist in introducing institutional changes that correct failures and increase student satisfaction and achievement [27,28].

Accordingly, satisfaction is multifaceted, largely determined by the students' perception of themselves and the environment of which they are part, including their perception of the curriculum structure and/or organization of the course, about the body of teaching staff and their involvement with students, the interpersonal relationships established between students during the course, their interest in the course, their expectations of employability and personal development, among other factors [23,29–32].

3. Our Objectives and Research Hypotheses

This research aims to (i) measure the academic satisfaction of students at the FIEPI-Campus Oeiras and (ii) understand how it presents itself in relation to the control variables gender, educational level, courses, and technological axes. Accordingly, the following research hypotheses were established:

Hypothesis 1. *FIEPI-Campus Oeiras students are satisfied with the institution;*

The framework of the research hypothesis 1 is based on [25,26] who, when conducting research on student satisfaction at Federal Institutes of Education, Science and Technology, found statistical evidence that students, in general, are satisfied with the institution, which can also be valid for the present investigation, considering that all Federal Institutes of Education, Science and Technology have similar organizational and pedagogical structures, whose purpose is the development of professional

and technological education as an educational and investigative process for the generation and adaptation of technical and technological solutions to social demand and regional peculiarities [1].

Hypothesis 2. *Academic satisfaction presents itself differently due to differences in educational profiles.*

H_{2a}. *Academic satisfaction presents itself differently depending on the gender variable;*

H_{2b}. *Academic satisfaction presents itself differently depending on the variable courses;*

H_{2c}. *Academic satisfaction presents itself differently depending on the educational level variable;*

H_{2d}. *Academic satisfaction presents itself differently depending on the variable technological axes.*

The conceptual framework of research hypothesis 2 is based on [16–19] for postulating that satisfaction can be considered an attitude of judgment, an affective response and/or a general assessment centered on a comparison between the expected and real results of a given product or service, which, in the case in question, is understood as the result of a comparison between an idealized image of the institution by different educational profiles, based on cognitive and affective components, with the real performance of the institution in its entirety.

4. Method

Data Collection and Analysis

The instrument used for data collection was a structured questionnaire originally developed by [33], considering that the technical procedure adopted was a survey. The instrument was structured in two sections, in which the first was intended to obtain information for the characterization of the sample and the second section, composed of 14 items, had the purpose of measuring student satisfaction with the institution.

Since satisfaction is understood as a latent variable [34], the 14 items for its measurement were measured using a five-point ordinal Likert scale of Concordance, developed based on Oliver's Expectation Disconfirmation Theory (Expectation and Disconfirmation) (1980) [35]. According to this author, consumers (in the specific case, students) form expectations regarding the performance and characteristics (attributes) of a certain product or service (e.g., teachers, classes, institution structure, etc.) that are later compared to their actual performance at the time of use, leading to whether or not they generate satisfaction through confirmation or disconfirmation of the expectations generated.

To validate the data collection instrument, especially the measurement items of the latent variable, at first, the instrument was applied to a random sample of 35 students, then Cronbach's Alpha was calculated, defined as a verification measure of the proportion of variability in responses [36], having obtained a Cronbach's Alpha of 0.805, which can be considered as good reliability, being between 0.8 and 0.9. However, the analysis of the final reliability, whose application was made in the total sample of the study (290 students) presented a superior result, with Cronbach's Alpha of 0.933, showing excellent internal consistency or reliability of the data collection instrument developed.

The study was conducted with a sample of 290 students from the FIEPI-Campus Oeiras. For the treatment, analysis, and interpretation of the data, SPSS Statistics software in version 24 and Numbers in version 5.0 were used. The statistical techniques used were of a descriptive, exploratory and inferential nature to describe, analyze, and interpret the behavior of the attributes under study, especially the degree of student satisfaction and how it was presented in the study sample. For this, at first, the Average Satisfaction Indicator (IMS) was calculated, obtained by means of the simple arithmetic mean of the 14 items developed to measure satisfaction, according to the following Equation (1):

$$IMS = \frac{1}{n}\sum_{i=1}^{n} X_i \quad (1)$$

where, n corresponds to the number of independent variables used to measure satisfaction ($i = 1, \ldots, 14$).

$$IMS = \frac{1}{14} \sum_{i=1}^{14} X_i \quad (2)$$

where X_1 = Satisfaction in studying at FIEPI, X_2 = Expectation about the physical structure, X_3 = Stimulating environment, X_4 = Incentive of Teachers to Study, X_5 = Expectation about teachers, X_6 = Expectation about the classroom, X_7 = Happiness to study at FIEPI, X_8 = FIEPI as the right choice, X_9 = Expectation about the library, X_{10} = Expectation about stimulating classes, X_{11} = Teachers' Incentives for Curiosity, X_{12} = Expectations about classes that bring real solutions, X_{13} = Happiness when talking about the institution, X_{14} = Expectation about re-enrolling at the institution.

The satisfaction measurement tool developed and implemented in the present research is based on the fact that in the context of Brazilian educational institutions, factors related to the teaching environment and the structural environment are the most relevant for determining academic satisfaction, as verified in other research studies [37–41].

The population of the present investigation is formed by 604 students from the FIEPI-Campus Oeiras. A sampling error of 4.15% and a significance level of 5% were assumed for the calculation of the sample size, which was determined by means of simple random sampling. In addition, a significance level of 5% was assumed throughout all of the analyses. The present research was approved on 23 January 2019, by the scientific committee of the Institutional Scholarship Program for Scientific Initiation of the Federal Institute of Education, Science and Technology of Piauí, meeting the criteria of notice no. 141 of 19 November 2018.

5. Analysis and Presentation of the Findings

5.1. Sample Characterization

Among the 290 students in the sample, 57.9% are female and 42.1% are male, with a preponderance of ages between 16–19 years (53.8%) and 20–23 years (26.7%) and average family income between R $100.00 and R $1,825.00 (82.4%). Regarding the level of education, 71.7% of the students attend high school, while 28.3% attend higher education. In relation to the variable courses and curricular years, the sample has the following distribution: Third Year of High School Integrated to the Technician in Administration (12.8%), I Module of the Subsequent Technical Course in Agriculture (11.4%), Second Year of High School Integrated to the Technician in Administration (10.7%), II Module of the Subsequent Technical Course in Informatics (9.7%), IV Full Course Module in Physics (9.0%), IV Module of the Bachelor's Degree in Administration (8.3%), II Module of the Subsequent Technical Course in Commerce (7.6%), Third Year of High School Integrated to Agriculture Technician (6.9%), VI Bachelor of Business Administration Course Module (5.9%), IV Module of the Subsequent Technical Course in Informatics (5.5%), VI Module of the Full Degree Course in Physics (5.2%), I Module of the Subsequent Technical Course in Administration (3.8%), Second Year of High School Integrated to Agriculture Technician (3.4%).

Regarding the technological axes, 49% of the total students in the sample are from the Management and Business Axis, 35.9% are from the Natural Resources Axis and 15.2% are from the Technological Axis, Information and Communication. The chosen courses were the first option on the part of 74.7% of the students, who chose Teaching Quality (25.9%) and Institution Reputation (19.3%) as the main factors that contributed at the time of their choices. In addition, 39% of the students considered themselves to be poorly informed at the time of enrolment, while 38.6% considered themselves to be well informed, pointing out that the main route of information at the time of their choices was Colleagues and Friends (32,2%) and the Institution's Advertising (21.7%). When asked whether they would recommend FIEPI-Campus Oeiras to their friends, 94.1% of the students said yes.

5.2. Exploratory and Inferential Analysis

The result of the Average Satisfaction Indicator (IMS), obtained by Equation (1), was 3.91 (s = 0.71), being quite close to the value 4, indicating that students are inclined towards satisfaction with the institution, in accordance with [42,43], when postulating that values between 4 and 5 on a five-point Likert scale, indicate a high level of evaluation of a given construct under analysis, responding to research hypothesis 1. Another verification can be made through the analysis of the standard deviation obtained, which was 0.71, pointing out that there was low variability around the answers about academic satisfaction by the students. The value of the IMS found is largely explained by the low values of the variables: X_9 = Expectation about the library ($\overline{x}$ = 3.32; s = 1.15), X_{10} = Expectation about stimulating classes ($\overline{x} = 3.58$; s = 1.03), X_{11} = Teachers' Incentives for Curiosity ($\overline{x}$ = 3.76; s = 0.94) e, X_3= Stimulating environment ($\overline{x} = 3.87$; s = 1.00).

To answer research hypothesis 2, it is necessary to check if there are differences in the average satisfaction for the variables gender, courses, educational level, and technological axes.

Bearing in mind that the gender variable is composed of two independent groups, the verification of the differences in the mean satisfaction was done through the application of the parametric *t*-Student test for two independent samples, whose assumptions are normal distribution or $n \geqq 30$ and unknown standard deviation. In addition, it was necessary to apply the Levene test to verify the homogeneity of variances due to the gender variable being composed of two groups of different sizes.

The proof value obtained by the Levene test was 0.960, so it can be said that the variances are not significantly different at a significance level of 5%. With regard to the *t*-Student test, whose proof value obtained was 0.395, it is possible to conclude that the average satisfaction is not significantly different in relation to the gender of the students in the sample, considering a significance level of 5%.

In order to verify the existence of differences in the average satisfaction for the courses, the One-Way ANOVA parametric test was used, which brings as basics and cumulative assumptions for its application the normal distribution in the different independent groups (verified through the Kolmogorov–Smirnov test), the homogeneity of the variances (verified through the Levene test) and the independence between the groups.

The results of the Kolmogorov–Smirnov test indicated that the normality of the variable under study could not be assumed, thus making the application of the One-Way ANOVA unfeasible. As an alternative, the Kruskal–Wallis non-parametric test was used to compare the distribution of satisfaction between different courses. The proof value obtained through the Kruskal–Wallis test was less than 0.001, indicating that it is possible to conclude that at least one of the satisfaction distributions is different for the courses analyzed at the 5% significance level.

Regarding the level of education, the verification of possible differences in average satisfaction was performed by applying the parametric *t*-Student test for two independent samples, first using the Levene test to verify homogeneity of the variances, considering the differences in the sizes of the two groups of the sample.

The proof value obtained by applying the Levene test was 0.583, so it is possible to conclude that the variances are not significantly different between the groups, assuming a significance level of 5%. In addition, the proof value obtained through the application of the *t*-Student test was 0.371, allowing to affirm that there are no significant differences in the average satisfaction for the educational levels of the sample, taking into account a significance level of 5%.

For the technological axes, the verification of differences in satisfaction is possible through the application of the One-Way ANOVA parametric test, which, as previously mentioned, has a series of basics and cumulative assumptions for application, such as the normal distribution in the different independent groups, homogeneity of variances, and independence between groups.

With the aid of the Kolmogorov–Smirnov test, it was possible to verify that the variable does not follow a normal distribution, requiring once again the alternative application of the Kruskal–Wallis non-parametric test to compare the distributions of satisfaction for the different technological axes. The proof value obtained by applying the Kruskal–Wallis test was 0.004, so it is possible to conclude that

at least one of the distributions of satisfaction is different for the various technological axes analyzed, assuming a significance level of 5%.

6. Discussion

Based on what was previously presented, it can be concluded that research hypothesis 1 was fully validated, since the IMS value obtained was 3.91 (0.71), allowing us to infer that students are slightly satisfied with the institution. The results that confirm the research hypothesis 1 are in accordance with the results of other authors [20,25,26] who, despite finding statistical evidence that students are slightly satisfied with the institution, point out that the perception of the lack of infrastructure resources (physical environment, e.g., library and laboratories) and gaps in the teaching infrastructure (faculty, e.g., stimulating and challenging classes) have a negative impact on student satisfaction, which is also true for the present investigation.

On the other hand, research hypothesis 2 has been partially validated, since satisfaction is different for students when considering courses and technological axes. The justification for this is based on the fact that satisfaction is multifaceted, largely determined by the perception that students have of themselves and the environment of which they are part, including here their perception of the curricular structure and/or organization of the course, about the teaching staff and their involvement with students, the interpersonal relationships established between students during the course, their interest in the course, their expectations of employability and personal development, among other factors which vary considerably in relation to the institution's courses and technological axes [23,29–32].

Without a doubt, our results point towards the existence of more demanding students (regarding the physical environment as well as the human factor, namely, faculty members' abilities to teach and engage students). This is in line with the proliferation of degrees and academic courses now available, meaning that performing well and making a good salary in the workplace is thus that much more difficult. As a consequence, we see that the measuring of student academic satisfaction is a growing concern, being increasingly more important for higher education institutions such as the Federal Institute of Education, Science and Technology of Piauí-Campus Oeiras (FIEPI-Campus Oeiras). One is only as good as what one measures and, thus, planning also takes on a new and more important role: One must plan and establish a gap (which needs to be closed) between the "as is" situation (identified by a quality assurance system) and the "to be" desired situation for the near future (the result of benchmarking and strategic priorities given limited resources).

Hence, gone are the times when students would be satisfied with their diploma in itself [44,45], requiring instead practical and usable lectures [46]. Nowadays, students are very aware of the soft and hard skills (e.g., teamwork and leadership abilities vs. specific measurable knowledge, such as in computer programming or accountancy) in high demand in the marketplace and even students graduating with high marks may be extremely dissatisfied if they are unable to land a [good] job. The end result may thus seem, to a certain extent, unattainable as student perceptions of what they require an academic degree to give them have become much harder to meet and satisfy. Students want to be entertained (by interesting lectures), they want to learn (preferably for the long-term rather than the short-term), and they want the latest technological resources [21] to be available to them while studying (including access to numerous databases such as Scopus and ISI Web of Science, as well as free access to software suites such as the statistics package IBM SPSS). All of the above will contribute to an institution's reputation, which in turn, will "rub off" on the students who graduate from the institution being, as a consequence, recognized by employers in diverse industries. We are in a new age of education [11] and institutions need to react accordingly.

7. Conclusions

As previously mentioned, the main objective of this investigation was to present an indicator for measuring student satisfaction of students at the Federal Institute of Education, Science and Technology

of Piauí-Campus Oeiras, in order to provide evidence of how it presents itself in relation to the different educational profiles present in the institution, establishing the following research hypotheses:

Hypothesis 1. *FIEPI-Campus Oeiras students are satisfied with the institution;*

Hypothesis 2. *Academic satisfaction presents itself differently due to differences in educational profiles.*

In general, the students in the present investigation are satisfied with the institution, since the value obtained from the IMS was 3.91 (0.71), leaving the investigation hypothesis 1 fully validated. However, the research hypothesis 2 was only partially validated, considering that satisfaction is diverse only due to the variable courses and technological axes.

The results obtained in the present investigation provide an important practical contribution to the monitoring and management of student satisfaction by educational institutions since it presents an indicator that reflects how satisfaction is presented, serving as a parameter for fault corrections and the implementation of potential improvements that increase the satisfaction and achievement of students, thereby increasing their chances of staying and their success in the institution. As theoretical contributions, we emphasize the fact that the results obtained in the present investigation confirm the findings of other authors [20,25,26] who specifically studied the Federal Education Network, making it clear that although students are satisfied with the institution, factors such as access to adequate infrastructure, stimulating faculty, and educational environment are of paramount importance for increasing student satisfaction. In addition, the results found in the present investigation are in line with other investigations carried out in other countries, such as the United Kingdom, Romania, and Portugal [7–10]. Specifically, the results obtained confirm that elements that make up the learning design instituted by the institutions, which ultimately determine the quality of academic services in a tangible as well as an intangible way, exemplified in the present investigation by the expectations that students have about classes, about support services, such as access to the library, and the educational environment as a whole, have a significant influence on student satisfaction, as pointed out by [8,10]. In a complementary way, the results of the present investigation bring evidence that the expectations that students develop about teachers, as well as their interactions with them, have a significant impact on their satisfaction levels. In this sense, according to investigations carried out by [7,9] in Portugal and Romania, the motivation and satisfaction of teachers become crucial for academic satisfaction to be achieved.

As limitations, it is worth mentioning that the investigation was carried out in only one of the institution's campuses, making it impossible to transfer the results to other campuses and other institutions of the Federal Education Network (External Transferability), considering that each one has particularities linked to its context, geographic location, teaching modalities, among others.

Refs [47,48] found evidence that a good relationship between students, colleagues, and teachers is essential to reduce student dropout, in addition to the fact that life satisfaction variables, as they are characterized as a global assessment, and affective relationships are related.

Accordingly, for future studies, it is suggested to investigate the relationship between academic satisfaction and student dropout and the influence that academic satisfaction has on life satisfaction.

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Article

Emotional and Spiritual Intelligence of Future Leaders: Challenges for Education

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Abstract: The study was focused on understanding emotional and spiritual intelligence, and leadership linkages. The aim of the study was to explore the relationship between emotional and spiritual intelligence and self-leadership skills of university students in the fields of management, as potential future leaders. The data were collected using three scales: Emotional Intelligence Scale (WLEIS), Spiritual Intelligence Inventory (SISRI-24), and Self-Leadership questionnaire. The study was conducted among 190 university students. The results obtained show that there are connections between emotional and spiritual intelligence and self-leadership. The study may be a good starting point for further research in this field and lead to reflection about spiritual knowledge on the leadership education program.

Keywords: spiritual intelligence; emotional intelligence; leadership; education

1. Introduction

Leadership education programs in universities have traditionally focused on such competencies as management and economics [1] in order to prepare good managers for organizations. It was related with the belief that only a leader with high intelligent quotient (IQ) can better understand and optimize organizational systems and their complexities. Many previous studies in the leadership literature have focused on the rational intelligence of leaders. The IQ for assessing human intelligence is commonly accepted as a ratio of rational and logical knowledge [1] that allow leaders to gain success. However, many employees who want to be leaders are eventually eliminated, despite their high logical intelligence [1]; and highly intelligent leaders are not necessarily more effective [2]. As a result of the further search for what makes a leader effective, attention was paid to emotional intelligence (EI), that was an important challenge for future leaders [3]. EI tried to explain why some employees are better as leaders than the others [4]. Some research has pointed out that feelings are the most crucial factor for leaders [5] and leaders and followers should possess rather emotional knowledge than technical knowledge [6]. Another research has indicated the link between EI and the performance of leadership [7,8]. Thus, teaching managers to build better relationships was crucial to the propagation of organizational performance systems [1]. Leadership education programs have focused on emotional intelligence as desired knowledge. However, in today's ever-changing business environment, there is a need for something more. After a period of fascination with the IQ and EI of a leader, the time has come for a new kind of intelligence. Beyond the awareness of intellect and relationship, the ability to find inner security in that external environment is a key for effective leadership. The term "spiritual intelligence" (SI) has appeared [9], and is considered as the foundation of both rational and emotional intelligence [10] (p. 57). In response to the need to meet the challenges of unpredictable circumstances, spiritual knowledge should be included in leadership training [1].

The IQ responses on how to lead; the EI—who you lead; and the SI—why you lead [1]. These questions can be starting points for leadership education development, because all three intelligences:

IQ, EI and SI, make up leadership intelligence [2]. This is important because of a limited number of research-linking intelligence, leadership and education [11]. Leadership education needs to be guided by a strong, up-to-date curriculum and cutting-edge knowledge, which provides the crucial leadership skills and competencies that students need to develop and sustain as future leaders. Although management is related to logical intelligence, decision making is based on beliefs and values as a guideline; this means spiritual knowledge [12–14]. Making managerial decision based only on cogent intelligence and reducing emotional and spiritual side of employees is 'a mistake' [12]. Modern leadership education should also include emotional and spiritual intelligence.

This study was focused on both emotional (EI) and spiritual intelligence (SI). Firstly, the study examined the level of EI and SI of university students in the field of management. This enabled the study to determine the needs for leadership education programs in the topics. Secondly, the study explored the correlation between the constructs: emotional intelligence, spiritual intelligence and self-leadership. Thirdly, it offered a study of the correlation between the subscales of these constructs.

This paper is structured as follows. The first section describes emotional and spiritual intelligence on leadership. Hypotheses of the field study were then developed under this section. The next section describes the methods and the data analysis that were used to support the field study. The remaining part of the paper concludes the findings, with directions for further research for leadership development in education.

2. Emotional and Spiritual Intelligence on Leadership

2.1. Emotional Intelligence of a Leader

The theory of emotional intelligence (EI) was popularized and linked to leadership by Daniel Goleman [7,15], and since that time, it has been considered as the most significant skill, necessary competency and proper behaviour of a leader [16]. EI is labelled as the awareness, assessment, and management of one's own emotions, as well as others' emotions [17–20]. Over the years, several EI models were proposed, to broaden knowledge about the abilities, personalities, and skills related to emotional side of man [21,22]. The commonly used metrics of emotional intelligence indicate four dimensions: appraisal of self-emotion, appraisal of others' emotion, use of emotion, and regulation of emotion, according to Emotional Intelligence Scale WLEIS [23]. The self-emotion appraisal dimension is related to the capability to recognize and express one's own emotions. The appraisal of others' emotion is related to the ability to observe and distinguish the emotions of other people. The use of emotion focuses on the skill to use emotions constructively. The regulation of emotion means regulating one's own emotions and managing one's own emotional experiences. This model was used in this study.

In the context of leadership, managers should not only identify the emotional states of their employees, but also regulate them [24]. Some research presents positive links between leaders with high EI and the happiness, satisfaction, mindfulness, trust, faith and commitment of workers [25–27]. It is related to a leader's ability to better understand their employees and adjust their leadership conduct suitably [28]. However, EI is not the only determinant of employee well-being, but has a profound impact on leadership effectiveness and success [29–31]. The managing of EI has a strong impact on success [32]. Many researchers have also stated that leaders with high EI influence organizational results [33], the functioning of a group and a team [32,34]; organizational change [35,36]; potential sustainable growth [37]. Many researchers' studies also included the relationship among emotional knowledge and leadership styles, like transformational or visionary leadership [38,39]. To summarize, the hypothesis is as follows:

Hypothesis 1: *Emotional intelligence has a positive relationship with self-leadership.*

2.2. Spiritual Intelligence of a Leader

Spiritual intelligence connects intelligence with spirituality as a new construct [10], and as a quotient of the level of spiritual leadership [40]. While spirituality is a sense of higher-consciousness and divine existence [10], spiritual intelligence is related to the skills to use divine aspects to enable goals achieving and problems solving [41] (p. 59). Spiritual intelligence is an internal ability, related to mind and spirit and its connections to the world [42]. However, this internal ability influences external ability. Thanks to spiritual intelligence, we can discover a deeper sense and use it to solve the complex problems of the present. Spiritual intelligence can develop a constructive trait and enable one to make use of the capability to face danger and anger. People with a high spiritual intelligence rate are more tolerant, honest, and full of affection to others in their life [43]. Spiritual intelligence allows us to also draw knowledge from the richness of our heart and the universe. Many authors have reported that it is a kind of intelligence that allows a sense of contact with people, the whole, a sense of its own fullness, seeing connections between diverse things [44]; and also understanding the significance of relationships to support the interconnections [10,45]. It is an ability to see spiritual aspects of the self and others, and interconnectedness [46]. Spiritual intelligence is an internal compass between what is internal and what is external, providing a sense of meaning and a significance to experiences of which we are the co-creators. Many authors have pointed to this sense of higher meaning and purpose [41,44,47] and critical approach to them [46]. One of the most important aspects of spiritual knowledge are questions 'why' or 'what if' to seek fundamental answers [44]. Spiritual intelligence is a self-consciousness that teaches us how to go beyond the sphere of ego closest to us and reach deeper layers of the potential hidden within us [44], for a better existence [48].

Many authors have stated the core elements of spiritual intelligence [41,48–50]. Although the elements of spiritual intelligence differ slightly, most of them are overlapping. The most frequently used words are ability, capacity and capabilities. Besides such capabilities as high consciousness, self-awareness, transcendence, mastery, sense of the sacred or divine, altruistic love, freedom [48,50], which may sound abstract, many other abilities can support us in everyday situations, for example, understanding and embracing everyday experiences, events, and relationships, using spirituality to solve everyday difficulties, engaging in moral behaviour, feeling a sense of meaning, trusting for oneself and others, and developing responsibility for wise behaviour [49]. It means that spiritual intelligence not only allows us to feel higher and deeper feelings in certain moments, but also helps us in our everyday personal and work life. It is very important, because we are not different at workplaces and outside our workplaces. We are the same both in our personal and our work-life situations, with a certain perspective, consciousness, self-knowledge, approach to difficult situations, solving problems or building relationships with people. Thus, what we think and do is expressed not only in our personal life but also in our workplaces. One of the concepts of spiritual intelligence includes critical thinking about existence, that is related to thinking about the spirit, the world, and the existence; personal meaning production—related to seeking a sense of meaning and purpose in the experiences of one's life; the expansion of conscious state—related to control of getting in the higher states of awareness; transcendental consciousness—related to recognizing the ways of attending transcendence; [46]. This model was used in this study.

Spiritual intelligence is crucial for leaders, in order to create spirituality in the workplace for followers. In a dynamic business environment, leaders have to seek inner peace [51]. Spirituality is needed for leaders to grow their own sense of identity, to find the purpose of their own work, and to support follower's values with a strong sense of meaning [52]. Spiritual leadership is based on the essential needs of people in order to gain a harmony of vision and value among individual employees and whole groups, which can increase organizational results [53]. Many studies have indicated that spiritual leadership is necessary for spirituality at all level of work: the individual, team, and organization [54,55]. It affects life and job satisfaction [56], motivation and commitment [57], organizational efficiency [58], productivity and performance excellence [59] and the flexibility and

creativity of the organization [60]. Spiritual intelligence might be considered as a driving power for a leader [61]. To summarize, the hypothesis is as follows:

Hypothesis 2: *Spiritual intelligence has a positive relationship with self-leadership.*

2.3. Relationship of Emotional and Spiritual Intelligence

Emotional and spiritual intelligence supports organizational principles, ethical values and all organizational decisions. However, there are only a few studies that have shown the need for all leaders to have emotional intelligence with spiritual strength and lead with more meaningful behavior, or the importance of the relationship between emotional and spiritual intelligence, and the efficiency of leaders [62]. The studies showed that emotional intelligence and spiritual intelligence are interrelated [48] and strengthen each other [63]. Spirituality growth enhances emotional awareness. This, in turn, impacts the competence of managing and controlling emotions, which further reinforces spiritual development [64]. Thus, emotional intelligence level affects one's use of spiritual intelligence [10]. Spiritual knowledge facilitates understanding reason and emotion [23]. Many elements of both emotional and spiritual intelligence are common. Spirituality develops the intrapersonal and interpersonal competences [44] that are the components of emotional intelligence. Emotional intelligence with the understanding of emotions—both our own and of others—is closely related to such good attitudes as humility, forgiveness and thankfulness [43].

However, there is still insufficient research to show the relationship between emotional and spiritual intelligence. Moreover, many research studies are theoretical or conceptual studies and were derived from an Eastern context. Thus, this leads to the follow hypothesis:

Hypothesis 3: *Emotional intelligence has a positive relationship with spiritual intelligence.*

3. Method

The study used an online questionnaire among students from Bialystok University of Technology in Poland. The data were collected in November 2019 from 190 students. The questionnaire contained three dimensions: spiritual intelligence, emotional intelligence and self-leadership. In this study, the SISRI-24 (Spiritual Intelligence Self-Report Inventory) was used [41]. The SISRI-24 questionnaire was primarily used for a sample of university students with satisfactory validity. Thus, the SISRI-24 was applied in this study to measure spiritual intelligence with its subscales: CET, TA, PMP, CES. In the SISRI-24 questionnaire, five-point scales from 0—'not at all true' to 4—'completely true' was used.

Next, the Emotional Intelligence Scale (WLEIS) proposed by Wong and Law [65] with four subscales: SE, OE, UE and RE were adopted in this study. The WLEIS also had sufficient reliability, with validation in many countries [65]. In this questionnaire, a five-point Likert scale, from 0—'totally disagree' to 4—'totally agree', was used.

In order to determine the abilities of leadership inherent in the students, the Self-Leadership questionnaire (SL), according to Houghton [66], was used with five dimensions: (LS1) self-goal setting related to set specific goals for yourself; (LS2) evaluating beliefs and assumptions related to ability to evaluate the accuracy own beliefs and articulate them; (LS3) self-observation related to awareness of own progress and keeping a track; (LS4) focusing on natural rewards related to among others seeking pleasant rather than the unpleasant aspects of own's work; (LS5) self-cueing with using concrete reminders (e.g., notes and lists) to help focus on activities. In this questionnaire, a five-point Likert scale from 0—'totally disagree' to 4—'totally agree' was also used.

The SISRI-24, WLEIS and Self-Leadership questionnaires were used in the Polish language.

3.1. Data Analyses

Descriptive statistics, reliability and validity were calculated for the SISRI-24, the WLEIS and the Self-Leadership questionnaire and the subscales. The Cronbach's alpha estimated the

internal consistency of each priori scale and subscale. Pearson correlations between the SISRI-24 total and the subscales: CET, TA, PMP, CES; and the WLEIS total and the subscales: SE, OE, UE, RE; and the Self-Leadership questionnaire and the subscales: LS1, LS2, LS3, LS4, LS5. The confirmatory factor analysis (CFA) was performed using structural equation modelling (SEM) with the STATISTICA program.

3.2. Participants

The study was conducted among 190 students from Faculty of Engineering Management at the Bialystok University of Technology in Poland. The students are educating themselves to become managers in the near future, thus they are potential future leaders. The survey allowed one to gather the information on the field of study, gender and years. Sixty-six percent (66%) of the respondents were female and thirty-four percent (34%) male; the students were from 18 to 24 years old; and all respondents study on different kinds of specialization in the faculty; however, all specializations were related to management.

4. Results

The descriptive statistics and Cronbach's coefficient alpha of the SISRI-24, the WLEIS and the Self-Leadership questionnaire, are presented in Table 1. Cronbach's alpha were: 0.90 for the SISRI-24 total; 0.92 for the WLEIS total and 0.90 for Self-Leadership total. The reliability indicates an acceptable internal consistency (i.e., alpha = 0.70 or above). The reliability is also acceptable for all subscales. The means of the SISRI-24, WLEIS and Self-Leadership were assessed as average. Self-Leadership was assessed as the highest by the respondents (mean_2.98, stand. deviat_0.64); next was emotional intelligence (mean_2.38, stand. deviat_1.24). The average of emotional intelligence is slightly higher than spiritual intelligence that has the lowest rate (mean_2.06, stand. deviat_1,29). It can be noticed that the particular subscales were assessed differently—from 1.65 (CSE) to 3.11 (SL3). The results obtained show that students possess skills to manage their own tasks, they can set and achieve the goals, and they are reflexive, because they can analyze their performance and try to focus on the good aspects of their work. These skills can also be good for them as future leaders. The students also possess quite good abilities of management, especially controlling their own emotions. Appraisals of other emotions are more difficult for the respondents. The subscales of spiritual intelligence were assessed to be low. The lowest rate reached a conscious state expansion that, in general, sounds quite abstract.

The results of correlations between the SI, EI and SL and their subscales are shown in Table 2. There are positive and significant ($p > 0.01$) correlations between SI and EI (0.508); SI and LS (0.462); and EI and LS (0.631). The results support the hypotheses. All subscales of three constructs: spiritual intelligence, emotional intelligence and self-leadership, have positive correlations (from 0.195 to 0.556). The strongest correlations are between personal meaning production (PMP) and use of emotion (UE) (0.556, $p > 0.01$), appraisals of self-emotion (SE) (0.540, $p > 0.01$), and appraisals of other's emotion (OE) (0.444, $p > 0.01$). Moreover, the rest of the subscales of spiritual intelligence, as well as emotional intelligence, have positive and significance correlations between each other, and with self-leadership. This means that these constructs and their subscales may influence each other and increase these abilities.

Table 3 and Figure 1 show the results of the structural model from the GLS-ML output. The confirmatory factor analysis (CFA) was used to test the validity of the constructs. The Chi-square value, df, root mean square error approximation (RMSEA), goodness-of-fit index (GFI) and normed fit index (NFI) was applied for $p > 0.05$. RMSEA in both constructs: spiritual intelligence and self-leadership, is below 0.01 which means a very good fit; in the case of emotional intelligence, this is below 0.05, which means a satisfactory fit. Moreover, GFI (>0.9) and NFI (>0.9) confirm a good fit. However, the subscale SL4 (focus on natural reward) which forms the construct of self-leadership was removed, because of a poor fit. It should be noted that SL4 had the lowest Cronbach's alpha indicator, as well as low Pearson correlations with other subscales from the above analysis.

Table 1. Mean, standard deviation and Cronbach's alpha of SISRI-24, the WLEIS and Self-Leadership.

	Mean	Stand. Deviat.	*n*	Cronbach's Alpha
SISRI-24 total	2.06	1.29	190	0.90
CET (critical existential thinking)	2.22	1.36	190	0.77
TA (transcendental awareness)	2.18	1.28	190	0.75
PMP (personal meaning production)	2.25	1.25	190	0.82
CSE (conscious state expansion)	1.65	1.28	190	0.84
WLEIS total	2.38	1.24	190	0.92
SE (self-emotion appraisals)	2.41	1.25	190	0.88
RE (regulation of emotion)	2.58	1.20	190	0.86
UE (use of emotion)	2.35	1.22	190	0.86
OE (others' emotion appraisals)	2.19	1.29	190	0.89
Self-leadership total	2.98	0.64	190	0.90
(SL1) Self-goal setting	3.05	0.83	190	0.87
(SL2) evaluating beliefs and assumptions	3.07	0.72	190	0.83
(SL3) self-observation	3.11	0.75	190	0.86
(SL4) focusing on natural rewards	2.78	0.83	190	0.72
(SL5) self-cueing	2.92	0.85	190	0.76

Table 2. Correlation among the subscales of spiritual intelligence (SI), emotional intelligence (EI) and self-leadership (SL).

SI/EI	EI	SE	RE	UE	OE	LS	LS1	LS2	LS3	LS4	LS5
SI	0.508	0.402	0.374	0.399	0.419	0.549	0.462	0.504	0.410	0.361	0.418
CET	0.324	0.237	0.330	0.211	0.301	0.475	0.415	0.401	0.407	0.267	0.387
TA	0.416	0.316	0.404	0.320	0.295	0.460	0.385	0.440	0.393	0.270	0.339
CSE	0.315	0.233	0.165	0.236	0.326	0.318	0.278	0.337	0.193	0.198	0.318
PMP	0.603	0.540	0.376	0.556	0.444	0.479	0.382	0.371	0.361	0.389	0.355
EI	-	-	-	-	-	0.631	0.531	0.538	0.563	0..519	0.413
SE	-	-	-	-	-	0.536	0.459	0.444	0.470	0.485	0.319
RE	-	-	-	-	-	0.497	0.437	0.434	0.484	0.382	0.341
UE	-	-	-	-	-	0.435	0.364	0.373	0.395	0.361	0.293
OE	-	-	-	-	-	0.480	0.382	0.422	0.425	0.404	0.328

$n = 190$, $p > 0.01$.

Table 3. Confirmatory Factor Analysis (CFA) of the constructs of SI, EI and SL.

	χ^2	df	RMSEA	GFI	NFI
Spiritual intelligence	1.91	2	0.000	0.995	0.993
Emotional intelligence	2.25	2	0.022	0.994	0.992
Self-leadership	1.99	2	0.009	0.995	0.993
Model	40.778	36	0.017	0.968	0.965

The SEM was used to test the factors that determine self-leadership (Figure 1). Perceived emotional intelligence was a significant predictor of self-leadership ($\beta = 0.456$, $p > 0.05$). Thus, the Hypothesis 1 was supported. The results obtained show that spiritual intelligence is also a significant factor ($\beta = 0.414$, $p > 0.05$) that supports the Hypothesis 2. These relationships mean that the higher the level of emotional and spiritual intelligence, the higher the level of self-leadership. It should be noted that spiritual intelligence is positively related to emotional intelligence ($\beta = 0.030$, $p > 0.05$), however, this relationship is not sufficient. Thus, this finding did not support Hypothesis 3.

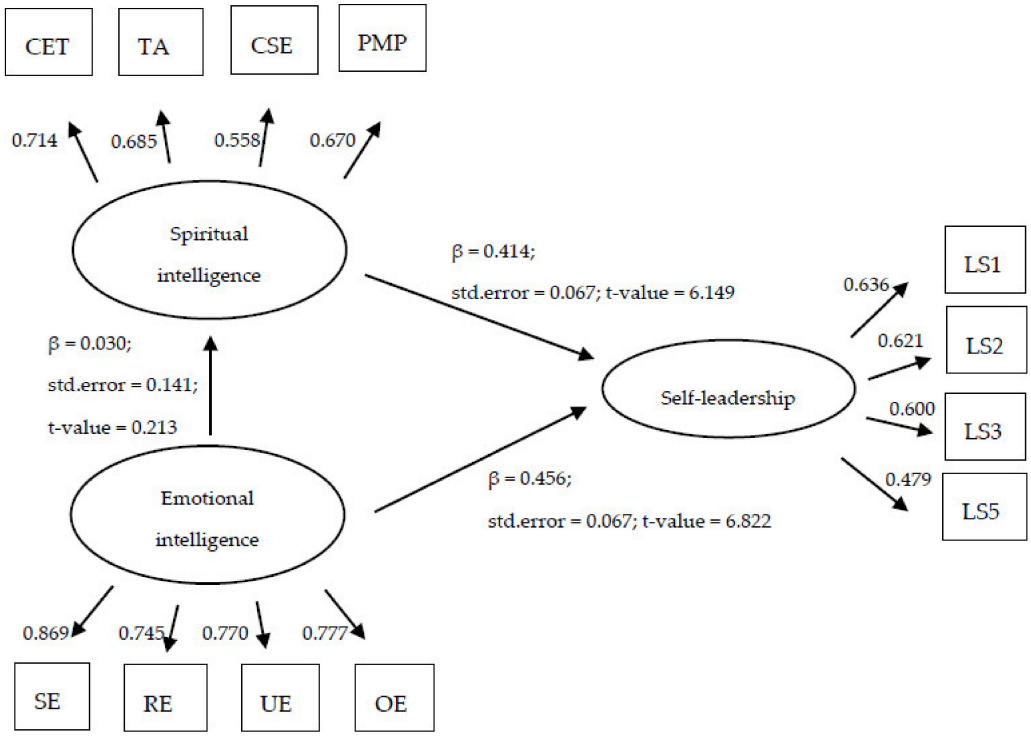

Figure 1. SEM model of emotional and spiritual intelligence and self-leadership.

The results of effects analysis for subscales of all three constructs presented significant positive correlations. CET (β = 0.714, p = 0.000), TA (β = 0.785, p = 0.000), CSE (β = 0.558, p = 0.000) and PMP (β = 0.670, p = 0.000) showed positive values with spiritual intelligence. SE (β = 0.869, p = 0.000), RE (β = 0.745, p = 0.000), UE (β = 0.770, p = 0.000) and OE (β = 0.777, p = 0.000) had positive values with emotional intelligence. All subscales of self-leadership also had positive values with the latent variable: LS1 (β = 0.636, p = 0.000), LS2 (β = 0.621, p = 0.000), LS3 (β = 0.600, p = 0.000) and LS5 (β = 0.479, p = 0.000).

5. Conclusions

The results of the study indicate that there is a significant and positive link between emotional and spiritual intelligence and the self-leadership of the students. Meanwhile, many previous research have indicated the correlation between emotional intelligence and leadership; this study draws attention to the fact that spiritual intelligence may also be important for leadership skills. Both kinds of intelligence are predictors of the ability of self-leadership. Self-leadership competence of the students can be useful in the future, when these students become leaders. To enhance leadership skills, emotional knowledge and spiritual knowledge may be considered as a subject in the leadership education program.

The results also presented that there is a link between emotional intelligence and spiritual intelligence, although it can be noticed that emotional intelligence is not a predictor of spiritual intelligence. Moreover, the results presented that both the spiritual intelligence and the emotional intelligence of the students had been assessed to be at quite average levels. Thus, the gap in possessing this kind of intelligence indicates that they should be strengthened under leadership courses for the development of leadership intelligence.

The results allow for the conclusion of some findings about the connection of spiritual and emotional intelligence and self-leadership in the context of education. The results showed that emotional knowledge should be further developed under the leadership education program, while spiritual knowledge should be introduced as a subject to the leadership education program. Education cannot be reduced to rational knowledge (as it is now) or emotional knowledge (which exists more

often), but enhanced to include spiritual knowledge. Spirituality according to literature becomes a crucial success factor for an organization by creating a positive work environment, and has effects on positive emotions. Leadership education often pressures the significance of self-interest and profit-making as a main potency of building competitive advantage. However, the dynamic, volatile, and unpredictable circumstances in organizational environment force changes in the approach to leadership education. Thus, it seems that the theory of spiritual intelligence is worth being further developed and introduced to the leadership education program. It is significant for improving the quality of leadership education.

As a further direction of the research, it would be worth it to conduct other surveys to confirm the above results. Firstly, the quantitative survey using a questionnaire is based on self-reported data. This causes the questionnaire to measure the subjective perception of one's own intelligence. Secondly, the structural equation modeling does not confirm the impact of emotional intelligence on spiritual intelligence. However, there is a positive link between these two constructs. It should be further developed to clearly confirm or exclude the correlation.

In conclusion, this study sheds light on recognition of the significance of emotional and spiritual intelligence of leaders. It can be inspired for expanding the theory of intelligence, especially spiritual intelligence that is still under research in the context of leadership education.

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Article

Spanish Adaptation of Motivational Climate in Education Scale with University Students

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Abstract: The aim of this study was to provide evidence of the validity and reliability of the dimensionality of the Spanish adaptation of two correlated subscales to assess motivational climate in the university education context: Mastery motivational climate and performance motivational climate. Two different studies with cross-sectional design and different samples of university students were used to accomplish this research (Study 1: 181 students, mean age = 20.83, *SD* = 1.76; Study 2: 354 students, mean age = 21.84; *SD* = 1.98). In Study 1, Exploratory Structural Equation Modeling, Confirmatory Factor Analysis (CFA), and reliability analysis of the scale were conducted. In Study 2, CFA, reliability analysis, discriminant validity, temporal stability, factorial invariance across gender, and nomological validity were managed through a regression model measuring the relationships between democratic and autocratic behavior, mastery climate, and performance climate. The final version of the Motivational Climate in Education Scale showed acceptable goodness of fit and values of discriminant validity, reliability, temporal stability, and invariance across gender. According to its nomological validity, democratic behavior was shown to be a statistically significant predictor of mastery climate, and the teacher's autocratic behavior was shown to be a statistically significant predictor of performance climate. This scale is a valid and reliable instrument to assess mastery climate and performance climate in the Spanish university educational context.

Keywords: validation; mastery; task; performance; ego

1. Introduction

In recent years, various studies have shown that teaching style could affect motivation during the students' training process [1–3] and, in addition, as other authors state [4], decades of research confirm that one of the keys to determining the quality of the students' experience is the motivational climate created by teachers in their classes. The relationship between dispositional and environmental factors has been demonstrated, such as the motivational climate created by other people (e.g., the teacher) [5], with different academic variables: Motivation [6,7], the perception of competence and autonomy [8,9], school commitment [10], adolescent adjustment [11], academic achievement [12], or academic performance [13]. For this reason, the role of the teacher is recognized amongst these environmental factors [14], and the motivational climate that their role generates is so important that some authors emphasize that it may be responsible for the students' academic success or failure [15].

The Achievement Goal Theory (AGT) [14,16,17], framed within the cognitive–social theories from an interactional perspective, has also developed research in the educational field. This theory starts from the basic idea that people are intentional organisms directed by our objectives, and that we rationally act according to them. In achievement settings, such as the educational environment, the main objective is to show competence [14]. These achievement goals are related to motivational patterns of adaptation and maladjustment, and constitute the main mechanism for determining

whether success or, conversely, failure results [14,16]. The classroom motivational climate is assumed to affect individual outcomes through the student's individual achievement goal, which is established according to the surrounding goal climate [18].

According to the AGT theory, two motivational climates predominate in the social contexts of achievement situations, such as classes in the educational environment: The mastery climate (also the task-involving motivational climate) and/or the performance climate (the ego-involving motivational climate) [19–21]. An ego-involving motivational climate is associated with performance and with normative standards, and judges a student's performance compared to that of others in the class [22]. Both teachers and students tend to adopt ability-demonstration goals, and this is associated with boredom, minimal effort, negative classroom experiences, and lack of teacher support [23–25]. On the other hand, this motivational theory argues that, in social contexts promoting involvement in learning and mastery (i.e., task-involving), the teacher values cooperation, effort, and improvement, which favor cognitive, affective, and adaptive behavioral responses on the part of the students [26]. The perception of this mastery climate is focused on personal improvement and achievement, and is based on the belief that success comes from work and perseverance [22]. Student achievement has been shown to be more effective when teachers strive to create a climate of learning and mastery rather than when they are more concerned with avoiding failure or demonstrating ability [27–29].

The motivational classroom climate generated by the teacher has been widely studied in different educational contexts, especially in primary [8,30] and secondary education [9,31–33]. Some studies have also been carried out in the university context [34,35].

Although several scales have been used to measure the classroom motivational climate in the Spanish non-university educational context, such as the Learning and Performance Orientations in Physical Education Classes Questionnaire [36] or the Classroom Motivational Climate Questionnaire [37], no scale has been adapted to measure the motivational climate generated by the teacher in university classrooms. It should be noted that the Motivational Orientation and Climate Scale [34] from the original Norwegian version of the Perception of Success Questionnaire [38] has recently been validated in Spanish (from the Dominican Republic, Latin America) [34]; this measures both the orientation and the motivational climate. However, despite the importance of studying the motivational climate and the influence on various variables at the academic level, a scale that specifically measures the university student's perception of the mastery climate (i.e., task-involving) and the performance climate (i.e., ego-involving) has not been validated in the Spanish educative context. This is the present work's main contribution to the international literature, since it is intended to adapt and validate a scale that allows one to specifically measure these two variables in Spanish classrooms, including university classrooms.

For all of the above, two different studies have been proposed, in which it is hypothesized that the factorial structure of two perceived motivational climate subscales will show adequate goodness of fit, and that the two factors will negatively correlate. Furthermore, the teacher's democratic behavior is expected to be a predictor of the mastery climate, while the teacher's autocratic behavior is expected to be a predictor of the performance climate. Therefore, the objective of the present study is to provide evidence of reliability and validity for the dimensionality of two correlated subscales from the Spanish version, measuring the motivational climate in university education. The "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) initiative [39] was used for the descriptions of Study 1 and Study 2.

2. Study 1

2.1. Materials and Methods

2.1.1. Study Design

This is an observational, descriptive, cross-sectional, and non-randomized study. Spanish university students from the University of Almeria (Spain) participated in the first study. The data were collected

during the first semester of the 2019/2020 course. The inclusion criterion to participate in the research was to be a graduate student in a presential university course. The exclusion criteria were: (i) Not giving consent for the use of the data in research and (ii) not completely filling out the data collection form.

2.1.2. Outcomes and Instruments

Motivational Climate in Education: In order to assess the motivational climate in educative classrooms, two dimensions that assess motivational climate perceptions were selected from the Norwegian version of the Perception of Success Questionnaire [38]. These two dimensions are made up of seven items and measure the motivational climate perceived by university students in class. The mastery motivational climate dimension (four items) implies that students are encouraged to improve their skills in relation to their own achievement level (e.g., "the teacher expects us to learn new skills and gain new knowledge"), while the performance motivational climate dimension (three items) stimulates competitiveness and social comparison (e.g., "students are encouraged to outperform others"). For the responses, a Likert scale was used from 1 (strongly disagree) to 5 (strongly agree).

2.1.3. Procedure

Firstly, the items from the two subscales of the Motivational Orientation and Climate Scale (MOC)—mastery motivational climate and performance motivational climate [38]—were translated using back translation [40]. Two translators translated the seven items into Spanish. Subsequently, two further translators proceeded to translate the items back into their original language (back translation). To judge the accuracy of the translation, the degree of coincidence with the original version was considered. The final version obtained was analyzed by a group of four education experts [41] to guarantee the items' adequate design in the construct measure, which was intended to measure and maintain the original meaning [40]. The experts evaluated the relevance and understanding of each item on a scale from 1 (strongly disagree) to 4 (strongly agree). If the mean item scores were <2.5, they were reviewed. If an item was not classified by at least three of the four experts within the theoretical dimensions of the scale, it was reviewed again. The global agreement of four experts on the relevance and understanding of the items was measured with the Intraclass Correlation Coefficient (ICC), using a mixed effects model and assuming an absolute agreement definition; the values obtained were: ICC = 0.85 for relevance and ICC = 0.92 for understanding. The Spanish version was administered to 45 higher education students between the ages of 18 and 30, all of whom expressed full understanding of the items. Thus, the final version of the Spanish Motivation Climate in Education Scale (MCES) was obtained.

Subsequently, the professors and those in charge at the education faculty were contacted asking for their collaboration and to give information regarding the purpose of the research. Students were informed by email to participate in the study. The instrument was finally administered via an online form, in which the importance of the research and how to complete the scale were briefly explained, as well as informing participants that they could leave the study at any time. All subjects gave their informed consent to be included before participating in the study. The study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Bioethics Committee at the University of Almeria.

2.1.4. Risk of Bias Assessment

In terms of bias control, it should be noted that there was no sample randomization since convenience sampling was followed. However, there was blinding between the participants and the researchers in charge of data treatment and analysis. Regarding selection bias, it was indicated that participation in the study was voluntary and the communication with students was by email.

2.1.5. Sample Size

Regarding the sample size (n = 181), the provisions set by Carretero-Dios and Pérez [42] were complied with in relation to the preliminary study of the items for scale validation: Between 50 and 100 participants with characteristics similar to those of the population, and between 5 and 10 participants for each item on the scale. According to the mean standard deviation established in a previous study [38] (SD = 1.12, performance motivational climate; 0.80, mastery motivational climate) and an estimated error (d) of 0.17 (performance motivational climate) and 0.12 (mastery motivational climate), a valid sample size for a 95% confidence interval (CI) was between 167 and 171 ($n = CI^2 \times d^2/SD^2$). A total of 181 students completed the study.

2.1.6. Data Analysis

The factorial structure was evaluated using Exploratory Structural Equation Modeling (ESEM) and a Confirmatory Factor Analysis (CFA). After verifying each item of the factorial structure and obtaining a final model, a CFA was performed to verify the factorial structure of the ESEM. The factors were correlated taking into account that the data were collected from different classes or groups of students; to avoid the non-dependence of the observations, the Mplus cluster option and COMPLEX function were used. The ESEM model was estimated by considering the recommendations of Marsh, Morin, Parker, and Kaur [43] so that all of the rotated loadings were freely estimated, and the Geomin oblique rotation was chosen with an epsilon value of 0.5 in order to facilitate the subsequent comparison of the factorial structure obtained [44]. Furthermore, in the absence of a secondary factor loading of >0.32, primary factor loadings of >0.50 were considered adequate [45] to maintain an item in a factor. Standardized factorial loadings (λ) were reported.

The models (ESEM and CFA) were tested using the robust maximum likelihood estimation method for continuous variables (MLR) [46], and the evaluation of the models was based on the following goodness-of-fit indexes: χ^2/df ratio values, the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) with its 90% confidence interval (CI), and the Standardized Root Mean Square Residual (SRMR). For the χ^2/df ratio, values <2.0 or <5.0 were considered excellent [47] or acceptable [48], respectively, <0.95 or between 0.90 and 0.95 (CFI and TLI), below 0.06 or 0.10 (RMSEA), respectively, indicating an excellent or marginally acceptable fit [49], and SRMR values <0.08 [48]. The descriptive statistics were calculated with SPSS 24.0, and the rest of the models (ESEM and CFA) were performed with Mplus 7.0.

The reliability of the scale was evaluated using different parameters: Composite reliability using McDonald's ω [50], Average Variance Extracted (AVE) [51], and Cronbach's alpha (α). Compared with the values traditionally used to assess reliability, such as α, the ω has the advantage of considering the strength of association between the items and the constructs, as well as the measurement errors specific to each item [52]. Reliability values >0.70 were considered acceptable. In addition, a temporal stability analysis was performed using the ICC and its 95% CI, considering values ≥0.70 as being adequate [53].

2.2. Results

2.2.1. Participants

A total of 181 university students participated, aged between 19 and 25 years old (M = 20.83; SD = 1.76). Of these, 76.2% were male. A further 19 students did not give their consent to participate in the data collection, so they were not included in the study. The data were collected in December 2019. There were no missing values in the data of the included sample.

2.2.2. Exploratory Structural Equation Modeling

The descriptive statistics of the items and the ESEM results are shown in Table 1. The ESEM (i.e., the preliminary exploratory analysis) verified the factorial structure of the MCES in two factors. The ESEM results showed high primary factorial loadings (>0.67) and secondary factorial loadings

below 0.04. The two factors were made up of seven items—four items in factor 1 (F1) and three items in factor 2 (F2); they showed the following goodness of fit: χ^2/df = 1.00, p = 0.288; CFI = 0.99; TLI = 0.99; RMSEA = 0.034 (90% CI = 0.000; 0.098), SRMR = 0.014 (Table 1).

Table 1. Item descriptions and exploratory structural equation modeling of the Motivation Climate in Education Scale (MCES).

					ESEM	
Items	**M**	**SD**	**Q1**	**Q2**	**F1 (λ)**	**F2 (λ)**
1. El/la profesor/a espera que aprendamos nuevas habilidades y obtengamos nuevos conocimientos y habilidades (The teacher expects us to learn new skills and gain new knowledge)	2.91	1.07	0.01	−0.61	**0.86**	0.00
2. El/la profesor/a solo tiene en cuenta a los estudiantes con mejor rendimiento (Only successful students are taken notice of)	2.87	1.23	0.04	−1.0	−0.21	**0.68**
3. El/la profesor/a se involucra para ampliar nuestra comprensión de los contenidos de la asignatura (The teacher is engaged in broadening our understanding of the subject)	2.81	1.10	−0.03	−0.58	**0.85**	0.03
4. El/la profesor/a presta más atención a los estudiantes con éxito (The teacher gives the most attention to the successful students)	2.97	1.24	0.13	−0.92	−0.01	**0.81**
5. El/la profesor/a anima a los estudiantes a practicar habilidades con las que aún no han tenido éxito (The students are encouraged to practice skills that they have not yet been successful with)	3.26	1.10	−0.18	−0.74	**0.81**	−0.04
6. El/la profesor/a anima a los estudiantes a superar a los demás (Students are encouraged to outperform others)	2.71	1.21	0.12	−0.99	0.03	**0.94**
7. La mejora es importante para cada estudiante (Improvement is important for every student)	3.18	1.17	−0.18	−0.79	**0.73**	−0.01

Note. ESEM = Exploratory Structural Equation Modeling; M = mean; SD = standard deviation; Q1 = skewness; Q2 = kurtosis; F1 = mastery motivational climate; F2 = performance motivational climate; λ = standardized factor loadings; factor loadings >0.50 (primary) are highlighted in bold.

2.2.3. Confirmatory Factor Analysis

Next, a CFA was performed with the seven-item model consisting of two correlated factors (Table 2). The model's goodness-of-fit indices were excellent: χ^2/df = 2.00, p = 0.023; CFI = 0.978; TLI = 0.965; RMSEA = 0.071 (90% CI = 0.026; 0.113), SRMR = 0.053. The standardized factorial loadings of the CFA can be verified in Table 1. Likewise, the reliability values were as follows: The mastery motivational climate (F1)—ω = 0.89, α = 0.88, and AVE = 0.65; the performance motivational climate (F2)—ω = 0.87, α = 0.87, and AVE = 0.70.

Table 2. Confirmatory factor analysis, standardized factor loadings for the confirmatory factor analysis (CFA) solutions.

Items	**CFA**	
	F1	**F2**
Item 1	0.85 **	
Item 3	0.84 **	
Item 5	0.82 **	
Item 7	0.73 **	
Item 6		0.91 **
Item 4		0.83 **
Item 2		0.76 **
F1 with F2	−0.32	

Note: CFA = Confirmatory Factorial Analysis; F1 = mastery motivational climate; F2 = performance motivational climate; ** $p < 0.001$.

3. Study 2

3.1. Materials and Methods

3.1.1. Study Design

This is an observational, descriptive, cross-sectional, and non-randomized study. Spanish university students from the University of Almeria (Spain) participated in this second study, but were from different courses from those in Study 1. The data were collected during the second semester of the 2019/2020 course. The inclusion criterion was to be a graduate student of a presential-mode university degree. The exclusion criteria were: (i) Not giving consent for the use of data in research, (ii) not completely filling out the data collection form, and (iii) having participated in Study 1.

3.1.2. Outcomes and Instruments

Motivational Climate: The MCES version used was the same as in Study 1.

The Scale of Democratic Behavior and Autocratic Behavior (ECDA): The Democratic Behavior (e.g., "encourages students to make suggestions on how to give classes") and Autocratic Behavior (e.g., "presents their ideas in a forceful way") subscales were used; they were validated in the Spanish university context [54] and were derived from the original Leadership Scale for Physical Education [55]. Each factor is represented by three items that are answered using a Likert-type scale from 1 (never) to 5 (always). In the present study, this scale showed an excellent goodness of fit: $\chi^2/df = 1.34$, $p = 0.220$; CFI = 0.99; TLI = 0.99; RMSEA = 0.031 (90% CI = 0.000, 0.074), SRMR = 0.02. Reliability: Democratic behavior—$\omega = 0.76$, $\alpha = 0.85$; AVE = 0.56; autocratic behavior—$\omega = 0.76$, $\alpha = 0.78$; AVE = 0.52.

3.1.3. Procedure

The professors and those in charge of the education faculty were contacted to request collaboration and to report on the purpose of the investigation. The education students were asked by email to participate in the study. The instrument was finally administered via an online form, in which the importance of the research and how to complete the scale were briefly explained, as well as informing participants that they could leave the study at any time. All subjects gave their informed consent to be included before participating in the study. The study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Bioethics Committee at the University of Almeria.

3.1.4. Risk of Bias Assessment

Related to risk of bias, in this second study, it should be noted that there was no sample randomization, since convenience sampling was followed. Despite this, there was blinding between the participants and the researchers in charge of data treatment and analysis. Regarding selection bias, it was indicated that participation in the study was voluntary, and the communication with students was by email.

3.1.5. Sample Size

With the total sample ($n = 354$), the confirmatory analysis requirements [42] of 10 participants for each item on the scale were met. For the nomological validity analysis, an a priori power analysis conducted using the Free Statistics Calculator v.4.0 software [56] indicated that a minimum sample size of 166 would be sufficient for the model structure to detect small effect sizes (i.e., $f^2 = 0.10$) with a power level of 0.95 and a two-tailed significance level of $\alpha = 0.05$ in a structural equation model (SEM) with four latent variables and thirteen observed variables. A total of 354 students completed the study.

3.1.6. Data Analysis

The descriptive statistics and correlations were calculated with SPSS 24 (IBM, Chicago, IL, USA). The CFA model to verify the factorial structure of the MCES from Study 1 was calculated

with Mplus 7.0 [57]; hence, the two factors were correlated: Task-involving climate (items 1, 3, 5, 7) and performance-involving climate (items 2, 4, 6). Insomuch as the data were collected from different classrooms, and to avoid the likely non-independence of the observations, the cluster option and the COMPLEX function of Mplus were used. Standardized factor loadings (λ) were reported. The model (CFA) was tested employing the MLR estimation method [46]. The same combination of fit indices was used as in Study 1 in order to check the model's goodness of fit (χ^2/df, CFI, TLI, RMSEA, SRMR). Scale score reliability estimates were also computed using three parameters: ω for composite reliability [50], AVE [51], and α. In addition, a temporal stability analysis was performed using the ICC and its 95% CI, considering values ≥0.70 to be adequate [53]. To obtain evidence supporting the discriminant validity of the constructs, the heterotrait–monotrait ratio (HTMT) of the correlations between factors was obtained, and values <0.85 were considered adequate [58]. The MCES invariance was tested across sex, employing the MLR estimation. Four progressively more restrictive models were run for each of the two factors: (1) Configural invariance, (2) weak invariance (i.e., invariance of the factor loadings/cross-loadings), (3) strong measurement (i.e., invariance of the factor loadings/cross-loadings and intercepts), and (4) strict invariance (i.e., invariance of the factor loadings/cross-loadings, intercepts, and residual variances). In regards to the measurement invariance, the nested models were compared taking into account the changes (Δ) in the goodness-of-fit indices (i.e., increases in RMSEA of at least 0.015 or decreases in CFI and TLI of at least 0.010 indicated a lack of invariance) [59]. To provide evidence of nomological validity, we conducted regression model analysis (direct effects) between factors of democratic behavior and autocratic behavior (latent variables) on mastery motivational climate and performance motivational climate (latent variables).

3.2. Results

3.2.1. Participants

The participants were 354 university students (59.6% male) from Education Sciences, aged between 19 and 29 years old (M = 21.84; SD = 1.98) from the University of Almeria, Spain. The participants were different from those in Study 1. In the data collected (January–February 2020), there were no missing values from the total sample. Apart from the total sample, twelve questionnaires were discarded because they were incomplete, and seven people did not consent to participate in this study.

3.2.2. Structure and Reliability Factor

Table 3 shows the descriptive statistics and correlations of the MCES items. The standardized factor loadings of the four items for the task motivational climate (F1) and the three items for the performance motivational climate (F2) of the MCES are shown in Figure 1. The seven-item model with CFA achieved an acceptable fit, as demonstrated by the goodness-of-fit values: χ^2/df = 4.00, $p < 0.0001$; CFI = 0.967; TLI = 0.946; RMSEA = 0.082 (90% CI = 0.067, 0.119), SRMR = 0.044. The reliability analyses showed the following values: Mastery motivational climate: ω = 0.90, α = 0.89, AVE = 0.68; performance motivational climate: ω = 0.89, α = 0.89, AVE = 0.72. The temporal stability analysis was evaluated using the ICC for the two factors, with values obtained >0.82, for which the instrument was administered to an independent sample on two occasions with an interval of four weeks between the two data collections. Regarding the discriminant validity, the value of the HTMT proportion in the correlation between the different dimensions was <0.85 [58].

Table 3. Descriptive statistics and correlations for the items of MCES.

Items	1	2	3	4	5	6	7
1 (F1)	-						
2 (F2)	−0.33 **	-					
3 (F1)	0.75 **	−0.27 **	-				
4 (F2)	−0.18 **	0.68 **	−0.21 **	-			
5 (F1)	0.69 **	−0.31 **	0.70 **	−0.22 **	-		
6 (F2)	−0.19 **	0.71 **	−0.18 **	0.78 **	−0.22 **	-	
7 (F1)	0.64 **	−0.34 **	0.62 **	−0.22 **	0.67 **	−0.16 **	-
Mean	2.85	3.01	2.70	3.12	3.13	2.84	3.07
Standard deviation	1.08	1.24	1.12	1.27	1.11	1.23	1.17
Skewness	0.02	−0.03	0.05	−0.015	−0.06	0.01	−0.04
Kurtosis	0.70	−1.04	−0.70	−0.1.04	−0.82	−1.05	−0.85

Note. **$p < 0.001$; F1 = mastery motivational climate; F2 = performance motivational climate.

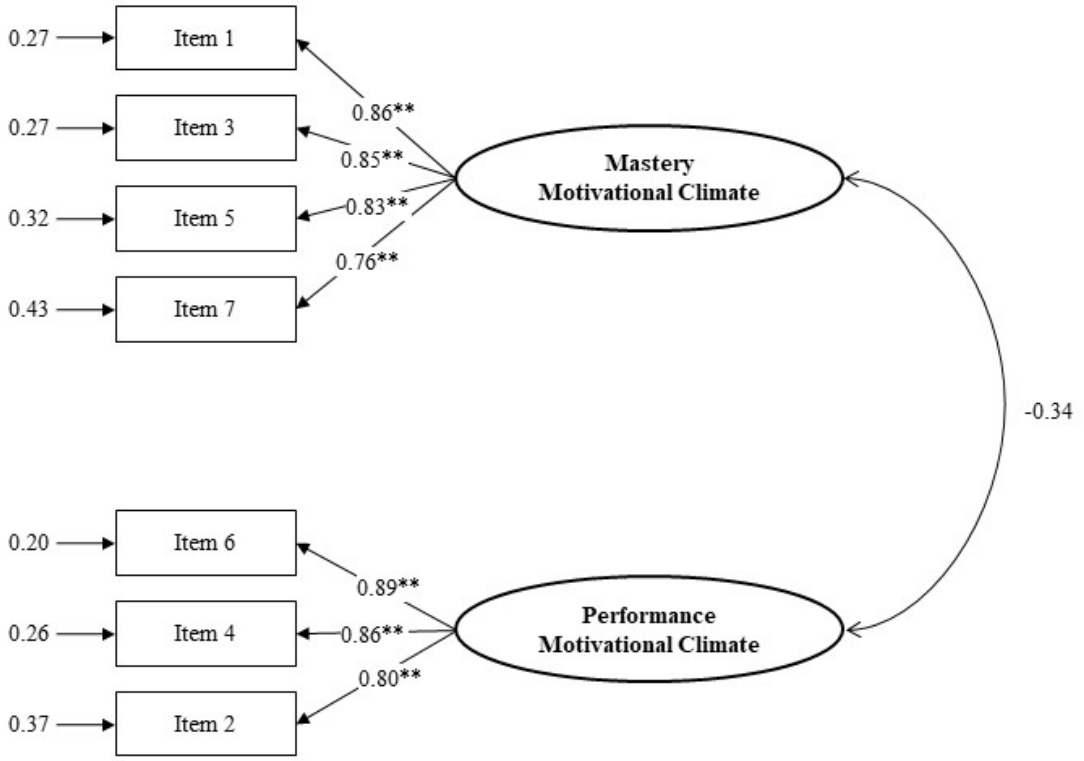

Figure 1. Confirmatory Factor Analysis—standardized factor loadings and residual variances. Note: The ellipses represent the latent factors and the rectangles represent the items; ** $p < 0.001$.

3.2.3. Measurement Invariance

The invariance according to gender (i.e., male = 211, female = 143) of the MCES was evaluated based on the CFA model, the results of which are shown in Table 4. Starting with a configural invariance (M0) model, invariance constraints were progressively added to the loading factors (i.e., weak invariance, M1), intercepts (i.e., strong invariance, M2), and residual variances (i.e., strict invariance). The values of these restrictive models were acceptable, except for the strict invariance, since the results were outside the cut-off values in the CFI. The weak and strong configural invariance models did not exceed the recommendations for RMSEA ($\Delta > 0.015$), CFI ($\Delta > 0.01$), and TLI ($\Delta > 0.01$), but, as can be seen in Table 4, the strict invariance showed a decrease that slightly exceeded the limits of the recommended values (ΔCFI = 0.013). However, the RMSEA and TLI values did not exceed the MCES recommended limits for invariance by gender in university students.

Table 4. Invariance test across gender for the MCES.

Model	χ^2	df	RMSEA [90% IC]	CFI	TLI	ΔRMSEA	ΔCFI	ΔTLI
Measurement across gender								
1.- Configural invariance	101.733 *	26	0.075 [0.056–0.112]	0.940	0.923			
2.- Weak invariance	121.780 *	31	0.073 [0.053–0.109]	0.938	0.922	−0.02	−0.002	−0.001
3.- Strong invariance	139.044 *	36	0.078 [0.059–0.110]	0.932	0.925	0.03	−0.006	0.003
4.- Strict invariance	160.160 *	43	0.082 [0.065–0.118]	0.927	0.929	0.07	−0.005	0.004

Note. χ^2 = Chi square; df = degrees of freedom; RMSEA = root mean square error of approximation; 90% CI = 90% confidence interval of the RMSEA; CFI = comparative fit index; TLI = Tucker–Lewis index; * $p < 0.01$.

3.2.4. Nomological Validity

The regression model (SEM) was performed with the bootstrapping technique (5000 samplings) because the Mardia coefficient presented a high value (18.78). Thirteen observed variables and four latent variables were introduced into the analysis. The results of the regression model estimated sample demonstrated a good fit with the data: $\chi^2/df = 2.89$, $p < 0.001$; CFI = 0.954; TLI = 0.954; RMSEA = 0.073 (90% CI = 0.061, 0.086), SRMR = 0.048. The factor loadings of the indicators across all of the model's latent variables ranged between 0.48 and 0.89. In our model (see Figure 2), the direct relationships between democratic behavior and the performance motivational climate were not significant, nor were the relationships between autocratic behavior and the mastery motivational climate. Table 5 also presents the point estimates as well as the bias-corrected bootstrapped 95% confidence intervals for the mediated effects. A significant positive relationship and high effect size was found between democratic behavior and the mastery motivational climate (β = 0.81), and between autocratic behavior and the performance motivational climate (β = 0.70). The model accounted for 70% of the variance in the mastery motivational climate and 38% of the variance in the performance motivational climate.

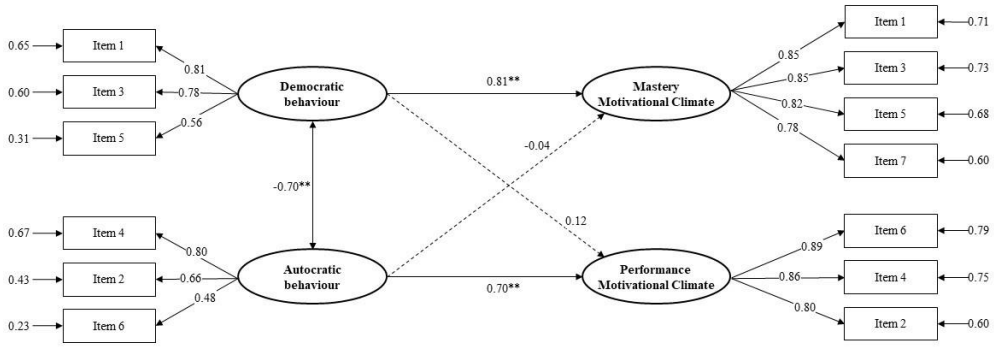

Figure 2. Regression model measuring the relationships of democratic and autocratic behavior with mastery motivational climate and performance motivational climate. Note: ** $p < 0.001$; broken lines represent non-significant relations.

Table 5. Analysis predicting mastery motivational climate and performance motivational climate with bootstrapping (5000 samplings).

	B				β					
		CI95%		SE		CI95%				
Sebscales	Est	LL	UL		Est	LL	UL	SE	*p*	R^2
Mastery Motivational Climate										0.70
Democratic behavior	0.83	0.63	1.11	0.12	0.81	0.65	1.00	0.09	0.000	
Autocratic behavior	−0.05	−0.27	0.24	0.13	−0.04	−0.22	0.18	0.14	0.640	
Performance Motivational Climate										0.38
Democratic behavior	0.15	−0.11	0.59	0.18	0.12	−0.09	0.46	0.14	0.309	
Autocratic behavior	1.05	0.70	1.66	0.25	0.70	0.48	1.03	0.14	0.000	

Note: B = regression weights; SE = standard error; β = standardized regression weights; Est = estimate; IC = confidence intervals; LL = lower limit; UL = upper limit; R^2 = variance.

4. Discussion

The objective of this study was to provide psychometric evidence on the dimensionality of the Spanish version of two correlated subscales of the MOC [38] in order to measure the perceived motivational climate with higher education students (MCES). Through the psychometric analysis of the scale of two factors correlated by two different studies, the final version of the MCES shows adequate levels of factor validity, discriminant validity, reliability, and temporal stability, as well as gender-based invariance. Thus, the first hypothesis is fulfilled. Furthermore, for nomological validity, democratic behavior was shown as a predictor of the mastery motivational climate, whereas the teacher's autocratic behavior was shown as a predictor of the performance motivational climate. Accordingly, the second hypothesis posed in this study is also fulfilled.

The present work focused on validating the two motivational climate factors (i.e., mastery and performance) of the original Stornes and Bru scale [38] for use in education. Like other validated scales for measuring the motivational climate in other contexts [36,60,61], a factorial structure with only these two correlated factors has been used. The adaptation of this scale to the educational context with university students has presented adequate values for the goodness-of-fit indices of the CFA. The original Stornes and Bru scale [38] also presented adequate goodness-of-fit indices at the psychometric level, but with four factors. In this regard, it should be noted that the four-factor original by Stornes and Bru [38] has recently been validated in Portuguese and Latin American Spanish (The Dominican Republic) by Gutiérrez, Tomás, Gómez, and Moll [62] to measure the orientation and the motivational climate in students from 14 to 18 years of age, and that, in general, it has presented adequate psychometric fits, both in the Portuguese version with the Angolan population and in the version with the Dominican Republic population. Likewise, Gutiérrez and Tomás [34] adapted this four-factor scale to the university population in the Dominican Republic, although this validation presents some indices below the acceptable value, such as the TLI value and the χ^2/df ratio.

Regarding reliability, the results of the present study demonstrate the high reliability of the two motivational climate dimensions, with values for α and composite reliability (ω) >0.86. In the study by Stornes and Bru [38], the α values for these two factors showed adequate reliability with scores >0.70; on the other hand, in the Dominican Republic university education version by Gutiérrez and Tomás [34], both the mastery climate factor and the performance climate factor presented α values <0.70, although the composite reliability values were adequate (>0.70). In the aforementioned adaptation by Gutiérrez and Tomás [34], the performance climate also presented α values below 0.70 in both the Angolan and Dominican Republic student samples, and the mastery climate achieved α values of <0.70 in the Angolan sample.

For the AVE values, the present study showed adequate indices in the two dimensions of the motivational climate with values >0.67, taking into account that the cut-off for the minimum acceptable values is >0.50 [53]. The scale also demonstrated adequate temporal stability. These are notable contributions made by this research to the literature, since none of the cited versions of this scale [34,38,62] show AVE values for these factors or a temporal stability analysis for the scale. In relation to the discriminant validity, it should be pointed out that an analysis using the HTMT ratio has also been performed in the present study, showing adequate values. The other cited studies do not conduct this HTMT analysis, although the correlation found between the mastery climate and performance climate was negative.

In relation to the analysis of invariance by gender, the scale is invariant at the configural level—weak and strong—although not in the strict invariance model. In the other four-factor versions of this scale, no factor invariance by gender analysis has been shown, although Gutiérrez et al. [62] presented invariance by country.

Regarding the relationship of the two motivational climate dimensions with teacher leadership, the results show coherence with the previous literature, given that democratic behavior is predictive of the mastery motivational climate, while autocratic behavior is predictive of the performance motivational climate. These results are in line with previous studies, such as that by Mohammadzade,

Zardoshtian, and Hossini [63], which demonstrated the positive predictive relationship between autocratic behaviors by the coach and the performance climate, whereas this relationship was not significant between democratic behaviors and the performance climate. Likewise, Alfermann, Lee, and Würth [64] (in athletes) and Bekiari [65] (in students) found a high and positive correlation between the teacher's democratic behavior and the motivational climate towards mastery, while the relationship between the teacher's autocratic behavior and the motivational climate towards performance was also positive and significant. Authors such as Barić and Bucik [66] and Smith, Fry, Ethington, and Li [67] (in athletes) and Habibullah and Sinha [68] (in the business environment) also highlighted the positive and significant relationships between democratic behavior and the mastery climate and between authoritarian behavior and the performance climate.

Despite the strengths and relevant results in relation to the psychometric properties of the MCES, this study also presents certain limitations that must be pointed out. First, the sample was selected according to convenience, not randomly, so the results obtained cannot be generalized. Second, the sample analyzed was made up of university students from a single university. Future research should examine the psychometry of this scale in students belonging to different educational levels (i.e., primary or secondary education) and other universities to determine if the factorial structure remains invariant based on this variable.

5. Conclusions

The Motivational Climate in Education Scale constitutes a valid and reliable instrument for evaluating the mastery motivational climate and the performance motivational climate during the teaching–learning process in the Spanish educational context. This two-correlated-factor version of the instrument presents a better fit than the four-factor scale (including the dispositional orientation and the motivational climate), and could contribute to more deeply analyzing the influence of the motivational climate generated by the teacher on the motivation, commitment, and academic achievement of students within their training process. These aspects are interesting from the teaching point of view, since a well-channeled motivational climate (i.e., mastery climate) based on work, consistency, improvement, and self-improvement could contribute to a greater teaching efficiency and favor students' cognitive, affective, and behavioral responses.

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Using Reflexive, Introspective and Storytelling Tools: Towards Becoming More Autoethnographic in Academia

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Abstract: The aim of this article is to show how autoethnography is a useful and revealing research methodology that should be encouraged in academia, especially in higher education. With objectivity, autoethnography, which is a relatively new approach, may be a path toward deeper cultural discussions that are so important in everyday life. Moreover, autoethnography leads to important reflexive and critical observations made by students. Autoethnography is a readily accessible, low-cost methodology and thus very appealing to students and younger researchers. With this article, the author exemplifies autoethnographic accounts and narrates three different stories that occurred while trekking with three different trekking guides in Patagonia (El Chaltén), Argentina. Argentinian culture, in South America, is the focus. Researchers need to be careful of misleading statements in the literature, such as that in Argentina modesty is apparently not tolerated. We found that two of our guides and leaders – Mariano and Liz – both had modest (and pleasant) demeanors. Hence, we conclude that it is important to maintain an open mind and resist categorizing people. This is a vital point of cultural studies that is often not taken seriously. Cultures are made up of individuals and thus many differences can be found in the midst of an attempted standardization, and the desire to put everyone in the same "basket".

Keywords: Patagonia; trekking; nature; goodness of humankind; culture; individuality; reflexivity; qualitative research

1. Introduction

> "Autoethnography is an avant-garde method of qualitative inquiry that has captured the attention of an ever-increasing number of scholars from a variety of disciplines." [1] (p. 1).

With objectivity, autoethnography may be a path that leads to a deep discussion on culture. As "Culture is a set of beliefs or standards, shared by a group of people, which help the individual decide what is, what can be, how to feel, what to do, and how to go about doing it" [2]. Moreover, autoethnography examines the differences that exist between different people, races, and regions around the globe.

In this article, the author narrates three different stories that occurred while trekking in Patagonia (El Chaltén), Argentina with three different trekking guides. Argentinian culture, in South America, is the focus. The narrator is of Anglo-Saxon origin (though mixed with Portuguese and Malaysian-Chinese) and his being multicultural related easily to the local culture in Argentina. The objective is to portray three very different personalities in the three trekking guides whom we had contact with. Books on national culture tend to set forth significant generalizations on what to expect when visiting a foreign country. This may be misleading, in some cases, and unfair in others. By having researchers increase awareness of the cultural interactions in which they are involved, not only will they become more

aware of their personal and professional identities but important insights may result. For example, Argentina is portrayed as having a high uncertainty avoidance [3]. Does this mean that they will deal badly with strangers? That they will be unfriendly to people they do not know? Will they be more aggressive, more anxious, as suggested by Usunier and Lee [4]? The author of this article perhaps saw aggression in one Argentinian tour guide but certainly not in the other two. Such generalizations can be dangerous.

When students discuss culture in a reflexive manner, they become more aware of themselves and their surroundings by objectively attempting possible categorizations and simplifications of reality. Autoethnography is about taking notice and paying attention to life as it goes by. Autoethnography is a low-cost and accessible means of performing research, involving introspective effort by the student/researcher while not incurring any special costs.

Additionally, trekking means existing in the absence of day-to-day technology, such as e-mail and smartphone apps like WhatsApp, Instagram, and Facebook. Trekking is thus a unique activity that can involve 10 h (in a single day) where one is cut off from the digital world. What effect does this deprivation have on individuals? Can activities such as trekking bring us closer to the natural world?

Initially, I found that I was dependent on my smartphone: always taking photos (to the point where my family complained) and holding my phone rather than enjoying the view and the company. As time passed my dependence weaned and I gradually let go of technology.

The article examines relevant literature, considers certain methodologies, and details three autoethnographic narratives regarding the author's experiences in December 2019.

2. A Look at the Literature

The aim of this article is to show how qualitative research and autoethnography, in particular, is a useful and revealing research methodology. For example, Deo and Gouzouasis [5], creativity is demonstrated in a performative autoethnography via expressive prose. While music is playing, memories of the author are shared. The author is a music teacher and thus an explanation is found for this communication. The story is about Grade 9 students and the danger of drugs. I have a child in Grade 9 and I can relate to the moving message of the article. The more talented the individual, the more there is a danger of following the wrong path. Exceptional students are not immune to addiction and death. A wrong significant other at this impressionable age (14-15 years of age) may be a future detriment. Is there an element of guilt, in the author's story, for having changed jobs and for having left her former student exposed to bad influences, someone she had been so close to? Deep sobbing leaves the reader suspended in emotion: "I'll never forget Megan. I lie on my side thinking of her creative potential and what could have been" [5] (p. 180). Are we inspired to take more care of our loved ones? I certainly now try harder, with my daughters. In conclusion, true stories move us. In academia we need to lose the fear of showing emotion and we need to lose the fear of writing interesting and captivating narratives. During my doctoral studies in 2007, a prominent lecturer told me that research was not supposed to be interesting. I think that my lecturer has since changed her mind, as her research has become increasingly more interesting. I feel this change in society happening as we speak. Academia has to find a new place for itself.

In Au-Yong-Oliveira, Branco and Costa [6], the author speaks of his experience abroad, in the Maldives islands inhabited by native citizens rather than tourists. There, the author comes into contact with a local traditional festival and is surprised by the harmony amongst the population, who practice Islam. Women and men stood on opposite sides of the street without visible dissatisfaction. The media often states that there is frustration and abuse in these environments, especially of women. The author instead saw amicability, accord, kinship, and, above all, peace. Furthermore, technology (i.e., smartphones and selfies) has showed that culture is more global than is normally supposed and advertised (Figure 1). Cultures may maintain certain traditions while also adapting to technology. Technology brings people closer together across the globe. Autoethnography involves reporting on what is supposedly different or similar between diverse national cultures.

Figure 1. Technology, smartphones, and selfies: noticing what is supposedly different or perhaps similar between different national cultures [6] (p. 856). Reproduced with permission.

Oito [7] is an author of another example of how autoethnography communicates emotions, specifically regarding whiteness, namely in a classroom in the United States. The article asks if teachers are prepared to be confronted by black youths in urban classrooms, detailing "the psychic pain that racism inflicts upon the racially othered children and youths who navigate urban classrooms under the scorching glare of whiteness" [7]. Only someone in a room "stuck in stillness" [7] (p. 251) may speak of glares and of "the loudness of the loaded silence" [7] (p. 251). Such vocabulary is often absent from academic discourse and "in the name of science" we are encouraged to be formal and distant. Yet is it not academia's purpose to educate both the younger as well as older generations, aiming for change and for development, aiming to reach out? How can we reach out and touch souls if we cannot use the full force of emotion derived from our words and experiences?

Storytelling involves sensemaking and plays a significant role in autoethnography. Prominent authors have "put forward a rebalanced model of sensemaking to make the sensible once again sensible and open up the sensemaking perspective to understand learning as a process that is more than mere interpretation" [8] (p. 3). How may we conquer and inspire our students if not through language and heartfelt prose, which communicates meaning and sense to the lives of those who are interested and who take the time to read our narrative? We may not have more than a single chance at such a change.

Not to say that this type or any type of storytelling is not a complex process. Past authors have framed it thus: "To make sense through processes of organizing and to find a plausible answer to the question 'what is the story?' requires a fusion of sufficient complexity of thought with simplicity of action, which we call simplexity" [9] (p. 5). Storytelling may require a confidence in the use of the correct language that other scientific methods do not require. Storytelling, including of our own experience, is a complex matter. Yet are we not living in complex times of exponential technological change that call for radical solutions to engage our intended audience?

With regard to Argentina, it is stigmatized as a politically, economically, and socially difficult country that has an oversimplified, acritical, and ignorant acceptance of poor leadership [10]. However,

Argentina is culturally idiosyncratic and differences are tolerated [10]. Argentinian culture inspires indulgence (featuring a high score of 62). Argentinians love to live joyously and have fun, even if in a loud fashion. Argentinians embody qualities such as sharing, collaborating, and socializing [11]. Argentina has a middle score for collectivism/individualism (46) and registers a high uncertainty avoidance score (86). This leads to an excess of rules and corruption [10,11]. Argentinian culture expresses masculine traits (featuring a score of 56 [11]), meaning that an achievement orientation is present, including a desire to excel.

As with all cultures there are exceptions and the above is but a generalization. This is an important point of cultural studies often not taken seriously: cultures are made up of individuals and many differences are found, even amid an attempted standardization and desire to put everyone in one "basket" [3,12]. However, as is shown below, we never know what we shall find at a travel destination (or, indeed, in our home countries).

3. Methodology

"Higher education has recently been recognized as a key driver for societal growth" [13] (p. 1) and research performed by students is an increasing requirement and expectation of higher education institutions. Students thus need to seek new and accessible avenues for their research endeavors. Autoethnography is one such avenue.

This study addresses two research problems: 1) why is autoethnography important? and 2) how may we help students produce more reflexive and introspective research through storytelling? In other words, how can we help students become more autoethnographic in academia?

The research design for relating the research problems "to relevant and practicable empirical research" [14] (p. 56) is an elaboration on the "framework for data collection and its analysis" [14] (p. 56). Furthermore, the research design is "a statement describing how the research is intended to be conducted" [15] (p. 193).

To aid recall, the use of a research diary, with regular entries, is suggested. The researcher will be able to maintain a trail of research activities and of the thinking processes developed during the research [15]. The research diary will be more or less essential depending on the length of the research period. For example, this study, which is exploratory in nature and in which the author told his own autoethnographic story, involved the description of events that spanned three days during a holiday trip, a period of time adequate for such a study [16].

Autoethnography is controversial but, if done rigorously, may lead to interesting results [17]. For this research study, a research diary and field notes were taken as the events took place (or soon after), to aid recall. Field notes for this study were of strategic importance.

Field notes may be of three types: methodological, descriptive, or analytic [18].

Concerning my methodological notes on collecting data, I suggest using a smartphone. Indeed, my smartphone has served me well on more than one occasion. Because smartphones are a natural part of contemporary environments (whereas a note pad or camera may make participants feel unduly nervous and wary, thus affecting the outcomes of the research effort), one may take notes, photos, videos, or do audio recordings without seeming too intrusive in the field.

"Descriptive notes are the meat and potatoes of fieldwork" [18] (p. 397) and they result from visual observation and listening. Descriptive notes may be in large volume. An advantage of using a smartphone to register notes is that one may use the "find" function to locate certain entries to our notes, according to a key word, thus saving time and frustration. This type of qualitative research may be tiresome at times and is often much more troublesome than doing an online survey.

Finally, it is also important to enter analytic notes in our research diary and field notes. This type of notetaking is essential and a unique contribution to our research. Analytic notes are often about small details and researchers should not be deterred from notetaking, even if the notes seem marginal or trivial in the grand scheme of the research.

Autoethnography is autobiography plus ethnography. It involves introspection [17] with regard to experiences involving the author (as storyteller). The main contribution lies in being able to see what is different. Handwerker [16] states that one has to "remember the basics [. . .] to produce ethnography, focus on similarities and differences among your informants". Furthermore, one has to consider, in the research design, that "cultural differences reflect variation in personal experiences. Culture evolves." [16] (p. 267). Table 1 summarizes how ethnography "flows out of a theory of culture" [16] (p. 274) and suggests elements to be included in the research design. Researchers should use labels and names to identify experiences. Definitions, in turn, will act as differentiators, especially when situations are ambiguous. Finally, intellectual or emotional associations will aid in the creation of meaningful mental constructions.

Table 1. Cultural phenomena, adapted from [16].

Cultural phenomena	Purpose
Labels, names	Identifiers of experience
Definitions	Differentiators
Associations	Meaningful mental constructions

Autoethnography is also reflexive and its main beneficial qualities are in education, as it "facilitates our questioning and moves us beyond our own taken-for-granted assumptions and sense-making of the social world, both professionally and personally" [19] (p. 173). It is also useful as it furthers research on different cultures and shows people customs, beliefs, and values that may be distinct in certain parts of the world. Autoethnography "is a relatively new approach to academic research, which at present would only be accepted by a small community of scholars" [15] (p. 16). It is a qualitative research method that relies on narrative and words [15]. Rich description [20] is essential in autoethnographic accounts: "One has to peek at one's immediate experience as if from a unique 'cultural window'" [21] (p. 58) (Figure 2). Therefore, I seek an "autoethnography that allows for innovation, imagination, and the representation of a range of voices in qualitative inquiry while also sustaining confidence in the quality, rigor, and usefulness of academic research" [1] (p. 1). I herein hope to make a contribution in that direction.

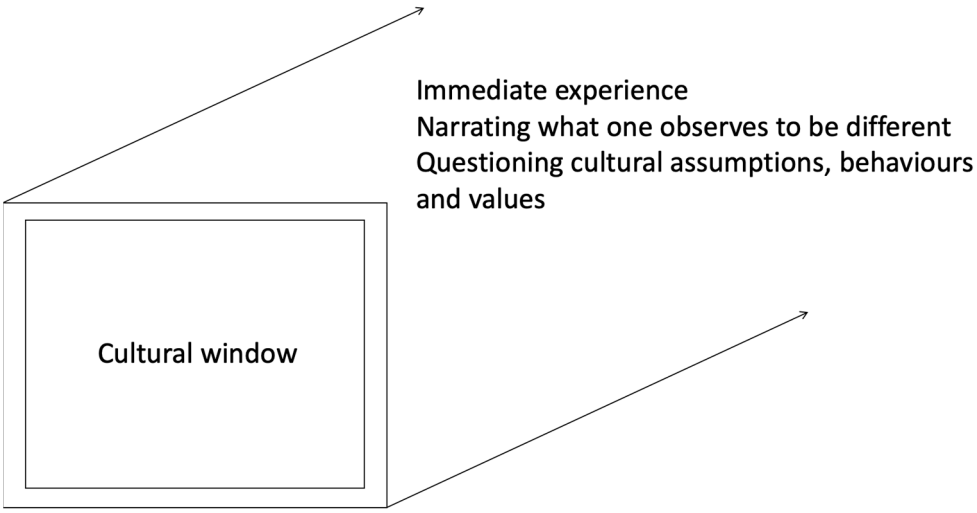

Figure 2. Autoethnography involves peering from a unique "cultural window" [21] (p. 59). Reproduced with permission.

The autoethnographic stories told in this study involve my family's December 2019 holiday trekking trip to El Chaltén, in Patagonia, Argentina. I hope to not only share my views on what I saw and experienced but also to transmit new knowledge on culture.

While on holiday, I asked those who I was interacting with, and thought would be a part of my storytelling, whether they consented to me writing about them. It is important to get early authorization (so as to not be disappointed later, after writing the article) and to exchange e-mails and contacts for posterior use. For example, you may later send the stories to the participants, for verification and validation purposes. In this study, the two names of the guides are real (Mariano and Liz); the third guide, who is not named, has had some details withheld, to make sure that he is not identifiable and to ensure that he is completely anonymous. To date, everyone who I have asked to name in my autoethnographic studies has agreed to be involved. I must also admit that some subjects were surprised at me wanting to research and write during a holiday. However, I see holidays as a unique opportunity to meet and interact with a culture new and unknown to me, thus providing good research opportunities.

This research study was shared with one of the tour guides, Liz Reyes, who confirmed the validity of what was written.

4. Autoethnographic Narratives

4.1. Story 1: At the Mercy of A Bad Trekking Guide in Patagonia, El Chaltén, Argentina

We had a hurried discussion amongst ourselves. Should we leave our trekking guide a tip? If so, how much? Should we invite him for a drink when we have finished the trek?

The 20-km trek to Laguna Torre had been a hard one. It was Christmas day (25th of December 2019) and perhaps we should have stayed at home and kept warm and dry. The rain at the top of the mountain (Figure 3) came down sideways in torrents, due to the wind. We were soaking wet and had to trek another three hours down the same route which had brought us to the summit.

Figure 3. Arriving at Laguna Torre in bad weather. El Chaltén, Argentina (December 2019).

Our trekking guide, we discovered, was pressing to get home early, due to our late start (we had asked our travel agency to start later, as we were delayed the day before, due in fact to the same

travel agency having made a mistake). For the duration of our trek, our trekking guide did not stop to see if we were keeping up, nor did he stop for us to have a look at the view. He stopped either to relieve himself in the woods or to put on his coat and gloves. When the rain stopped, he stopped to take his coat and gloves off. We were not the center of his attention; rather, he was the center of his own attention.

I was curious as to what motivated our trekking guide. Did he resent us, being apparently affluent Europeans? He did say that he had never been to Europe, that neither it nor the USA interested him.

"Are you married? Do you have kids?" I gathered the courage to ask. Our guide then gave me a brief account of his life.

He had been married before, yes, and from his first marriage had had a child, now 22 years old. He had never wanted more than one child. Children are time-consuming, he said, and difficult to raise. Besides, they are very expensive. I told him that in Europe, having one child was normal. He replied: "Here [in Argentina] it is not like that. People have three, four, or five children. And they never break out of being poor.

"I am now separated from my second wife. I believe I did not come to this world to be unhappy or to suffer. Thus, if something annoys me I just leave. I do not like children." This last confession came as a surprise to me, his candid admission that he did not like children. I had two young girls, aged 11 and 14, who were with us during the trek.

Earlier, the trekking guide had said that he went to Asia during the winter to teach Spanish. I asked him if he stayed in Asia for three months or more. He replied, "I stay for five or six months. I go when it gets boring here. I take off. I am very selfish, I suppose."

I appreciated his candor and honesty.

Our trek was coming to an end and I finally had the answer to my question, concerning the tip for our trekking guide. As we parted, he instructed us to our hotel: "Your hotel is quite close. There are some steps over there. Go down them, all the way down, then turn left and left again, and then right. Hotel de Las Piedras. You cannot miss it. This is my neighborhood, this is where I live. I shall stay here."

The houses in the neighborhood were of different shapes and sizes, but were generally very small and in some cases (if not all) not projected by an architect or engineer.

The trekking guide cordially shook our hands. I shook my head at my wife. No tip; she understood. Later, I explained that our trekking guide was not interested in tips. He worked to get by, nothing more, had no ambition other than that. Being nice only up to the point whereby he could keep his job.

My stepson ventured that if our trekking guide did not like children then he should not be a teacher. I agreed. However, everyone who does not like their job, in my opinion, has the wrong job. The vast majority of the world's population probably falls into this category. I have not liked all of my jobs during my lifetime, yet the bills must be paid. We cannot all be like Cristiano Ronaldo, the ingenious footballer, who I imagine loves his job. Yet we should still aspire to love our work like Ronaldo, should we not? However, what if we do not have the chance or opportunity? Preparation and luck make for opportunity; be prepared and you may get lucky. Otherwise, you may end up working for customers you hate or, at the very least, dislike. This is, at all costs, a life I do not want for my children.

I shall thus work to educate and prepare. Should not all good parents do the same?

4.2. Story 2: A Challenging Trek in El Chaltén, "Senda al Fitz Roy"

Thankfully, our next mountain guide was exceptional.

Mariano Casé was 35 years old and had been a mountain guide for 13 years, 10 of which were in El Chaltén. Mariano said that he had to have an outdoor job; if he were to be locked inside all day he would be very unhappy. He had a passion for nature and fresh air. Mariano was patient, informative, and had a pleasant and happy demeanor (Figure 4).

Figure 4. With our trekking guide Mariano Casé. A memorable trek on Boxing Day, 2019.

The Fitz Roy trek toward Laguna de los Tres involved a steep one-hour climb, to 1200 m. The first one-third, before resting, was done under the scorching hot summer sun. I was exhausted yet motivated to get to the top as the sun was shining. The visibility would be good.

As I trekked, I followed Mariano's footsteps exactly, placing my feet where he put his. It was an uneven and rocky climb, which turned into steep switchbacks nearer the top. Being with an expert trekker gave me the confidence I needed to make it. This phenomenon may be considered as positive contagion [22]. I did not need to think, but act. In following a competent leader, my performance and perception of the task improved—the mountain did not seem so steep and difficult, after all.

Mariano encouraged me to get to the top of the Fitz Roy trek, to see Laguna de los Tres. Without him I would not have made it. I saw that this 22-km trek and that challenging part of the journey were a test of character. Many thoughts went through my mind as I pulled my 84 Kg overweight body up the mountain. I was exhilarated when I made it to the top of Laguna de los Tres (Figure 5). The view was breathtaking. The sky was clear. I felt that all was well in the world. Mariano high-fived me. It was as much his victory as it was mine. "Just 2- minutes to go … 15 … 10 … 5 … 2 min … you are almost there!" Mariano had said. We are so much stronger in pairs, collaborating. Alone, I would have not attempted the climb at all (due mainly to an injury I incurred in my youth).

However, certain challenges are also a personal and lonely journey. I sang and hummed to myself while climbing. Said positive words, positive self-talk: "You can do it."

Mariano was very positive. My stepson reminded me afterwards to write about positive experiences and positive people. He was right.

My youngest daughter lost her cell phone and jacket on the way up the mountain. After the trek, Mariano took the trouble to go to the lost and found booth and managed to recover her items. This was beyond what was required of him and we were delighted. Late in the evening, Mariano came to our hotel to give us my daughter's lost items. He had a drink with us upon arrival in El Chaltén.

This was Argentinian culture at its best. Cheerful and somewhat loud socializing. Indeed, it was a memorable trip on Boxing Day 2019.

Figure 5. Laguna de los Tres, Senda al Fitz Roy, El Chaltén, Argentina (December 2019).

4.3. Story 3: The Trek to Laguna del Diablo and the Principle of Reciprocity

Our last trek in El Chaltén was to Laguna del Diablo (Figure 6) and it was a difficult one. Although it was just under 17 km, we trekked in heavy rain in the woods on uneven ground that sloped uphill and upriver. We had to climb over roots and across wet areas. I was thankful that I had waterproof trekking shoes. However, not all of our group was so lucky. Having wet socks was unpleasant and not everyone packed waterproof trousers.

Figure 6. Laguna del Diablo in El Chaltén, Argentina (December 2019).

Our trekking guide was 30-year-old Liz Reyes. She had worked 10 years as a tourism guide and had only recently qualified to become a trekking guide. They were distinct professions, Liz said. Thus, she was inexperienced and this perhaps made her better as a trekking guide. Liz was eager to please and was flexible and attentive, taking photos and videos of us upon our request. Do we get spoiled by the routineness of our work? Should we change jobs often, perhaps every 10 years, to avoid that?

Again, I benefitted from following Liz up the path. When I experienced difficulty in the ascent, in the rain, I followed Liz and soon found the "transference of beneficial properties" (again, a positive contagion) [22] (p. 1).

The sun came out after lunch. This changed our moods. There is nothing like good weather and sunshine.

Liz let me lead on the trek back. This was a good practice, as trekking guides move fast and agilely, perhaps leaving weaker trekkers behind. Liz allowed a weaker trekker, like me, to set the pace while she brought up the rear. This did not mean that Liz did not pay attention to us. When my youngest daughter fell, tripping on her undone shoelaces, Liz oversaw me tie a better shoelace knot for her, one that would not come undone.

I must say that I was taken aback by the culture of sharing and socializing institutionalized in Argentina. Liz shared her "mate" (a local form of tea, which she made with her flask of hot water and special cup and "mate" leaves) with our driver, going back to the hotel. On the way to El Chaltén, from El Calafate, Liz had done the same with us (by coincidence, we had travelled together). This was something I had perhaps expected to see in an Argentinian culture, a culture of proximity and friendliness.

Our two trekking guides, Mariano and Liz, perhaps being younger than our first trekking guide, were more hopeful, helpful, and positive. Whether genetic or acquired during one's childhood or later in life, there are differences between people. There are many good people, but there are bad people too. Give and thou shall receive. The principle of reciprocity [23]. Yet not everyone wants to give first.

5. Discussion

Autoethnography is a voyage of self-discovery for the researcher, who is given to both introspection and observation. Major objectives of academia include teaching one how to observe and be self-aware (of the shortcomings, differences, and strengths of one's culture). Self-scrutiny leads to "the formation of an individual's professional identity" [24] (p. 339), which is an objective of contemporary education [24].

Autoethnography approximates realities—the theoretical and the "real" (i.e., professional). One needs to consider that "the classical design of the pedagogical course does not favor the maximum attainment of the predefined objectives. The break between academic knowledge and professional knowledge is the main cause [. . .] It is a question of adopting the reflexive posture to maximize the relations between the theoretical bases and the teaching practices by exploiting all the tools offered" [25] (p. 300). Tools such as introspection, reflexivity, and storytelling.

The term autoethnography is often absent from the index sections of methodology manuals [18,26,27] and absent from the content of such books. Autoethnography is in its infancy and is seen to be the result of pioneering work by Ellis, Adams and Bochner [28] less than a decade ago.

On the other hand, a 15 April 2020 search on Scopus.com with the search terms "autoethnography" or "auto ethnography" in all fields revealed 10,696 documents. Therefore, autoethnography has made a place for itself in one of the main academic databases for business studies and the social sciences.

One such document on Scopus equates autoethnography to hope, stating further that "autoethnography turns the research lens inward and takes seriously the idea that the study of self is legitimate. It allows for the exploration of reflexivity and encourages a journey that plumbs interior space" [29] (p. 741). Autoethnography is important because it presents and secures meaning to situations and relational experiences [29].

The need for autoethnography may arise where: (1) There is a close relationship between young researchers and their lecturers or supervisors; autoethnography is not easy to undertake and involves

courage, guidance, and savoir faire; (2) there is a lack of funding for in-depth research efforts such as those involving several hundred interviews done abroad with executives in a foreign language (such an effort may involve hiring a research firm to gain access and do the field work, which is often beyond the financial possibilities of researchers in less affluent countries); (3) time is lacking for more "regular / standard" research efforts by lecturers in poorer environments who may be overworked in an education system where there are more hours lectured, per week, by lecturers than in richer countries; (4) the researcher is able to live life and analyze that life, as it occurs, at the same time—travel is beneficial to this occurrence; (5) certain cultures (e.g., Anglo-Saxon) are less personal and more distant than, for example, Latin cultures, and thus may be less inclined to write reflexive and introspective stories about their lives. Yet such an inclination will certainly differ from individual to individual and generalizing who will want to perform autoethnographic research should be avoided.

Autoethnography may open new research avenues, leading to the generation of important knowledge, and thus deserves more attention, so that its popularity in future may increase further.

During my first trekking trip, I discovered nature, socializing, and self-actualization. In the outdoors, one suffers from the elements, rain, wind, and snow, and we must accept what nature offers us. We may travel 10 km for a view only for clouds or fog to get in the way. Trekking, as with many other activities, is unpredictable. With no cell phone connection or Internet to distract us, we are left alone with our thoughts. Additionally, we may choose to talk to our trekking companions. We may observe nature. Thus, I have found that trekking-lovers are nice people. Most do not litter or otherwise harm the environment.

We also witnessed first-hand how selfless trekkers can be. When my daughter lost her mobile phone and jacket, someone carried these objects nine kilometers to hand them in at the lost-and-found booth, in town. Moreover, we were impressed by our guide who found these valuables.

Travelling abroad allows one to experience a different culture and thus ideally reflects the process of autoethnography, as culture is a central aspect of this approach [28]. Autoethnography exists "in order to understand cultural experience" [28].

Travel is about getting to know how other people live. In this study, we saw how we had different trekking guides, despite all being from Argentina. From the selfish, indeed living only for oneself, to the collaborators and competent leaders. At times, we may have forgotten the tremendous diversity found in a country or small environment, such as El Chaltén. Hofstede [3] (p. 9) defined culture as "the collective programming of the mind that distinguishes the members of one group or category of people from another," which I find inaccurate and misleading. Is it an exaggeration to claim that being humane and loving life are virtues found everywhere? One has to only read the news to read stories about war and other atrocities. In sum, all Argentinian individuals do not share the same traits, despite what we are led to believe in an effort to simplify life's complexities.

Being more aware that theories abound, but are different from laws – in that they are less universal – will lead to the creation of greater and more careful theorists.

Introspection is seen to be self-healing to one's woes, which is another important benefit to writing reflexive pieces. Becker [30] chose to describe individual reactions to chronic pain (the survey had 192 responses, from eight countries). Pain, they found, is related to identity construction. What can be more personal than such a characteristic as one's reaction to pain? The article also adds value when it analyzes pain according to those who experience it. It is an article about reflexive thought and introspection. Surprisingly, those in chronic pain want to narrate the pain they are feeling: "For providers to better understand patients' chronic pain, results indicate they would like providers to inquire about how pain impacts their daily activities, relationships, work responsibilities, goals, and dreams using open-ended questions. These low-stake questions can facilitate emotional disclosure, increase feelings of support, and allow for co-morbid linkages." [30]. The fact that the patients' knowledge is subjective does not affect the results and the author concludes that the exchange positively deepens communication, with emotional benefits and increased well-being, as other authors have similarly concluded [29].

Reflexive introspection "challenges canonical ways of doing research and representing others, and treats research as a political, socially-just, and socially-conscious act." [28]. By making students and researchers more socially-conscious, the problem of long-term learning may be solved, as individuals narrating stories about their experiences will necessarily ask questions related to their area of training – be it politics, sociology, tourism, or business management. Students will no longer act without thinking, merely memorizing without understanding, as is often the case in higher education [31].

The autoethnographic stories told herein exemplify how people are different, as each person has inevitably had a unique path that he or she may in turn interpret differently. How we view ourselves and our environment may lead us to frustration and a sense of rebellion against the "cards" that life has dealt us, or may lead us to additional learning and an evolution of character. By being open to learning, we become open to change. Not everyone views change in the same way and not everyone is open to change. Like our first trekking guide, some have made the decision to close themselves off to the world, peeking out only to satisfy their own needs and to collaborate as little as possible with anyone else in the process. The other two trekking guides, on the other hand, acted as if they were spreading happiness and goodness in the world.

Beware of statements in the literature such as "in Argentina, Bolivia, and Mexico, modesty seems not to be tolerated" [10] (p. 683). Two of our guides and leaders – Mariano and Liz – both had modest (and pleasant) demeanors. Keep an open mind and do not be quick to categorize people. Life will be fuller and less disappointing, in a good way, as we learn again, each day, that goodness exists (Figure 7).

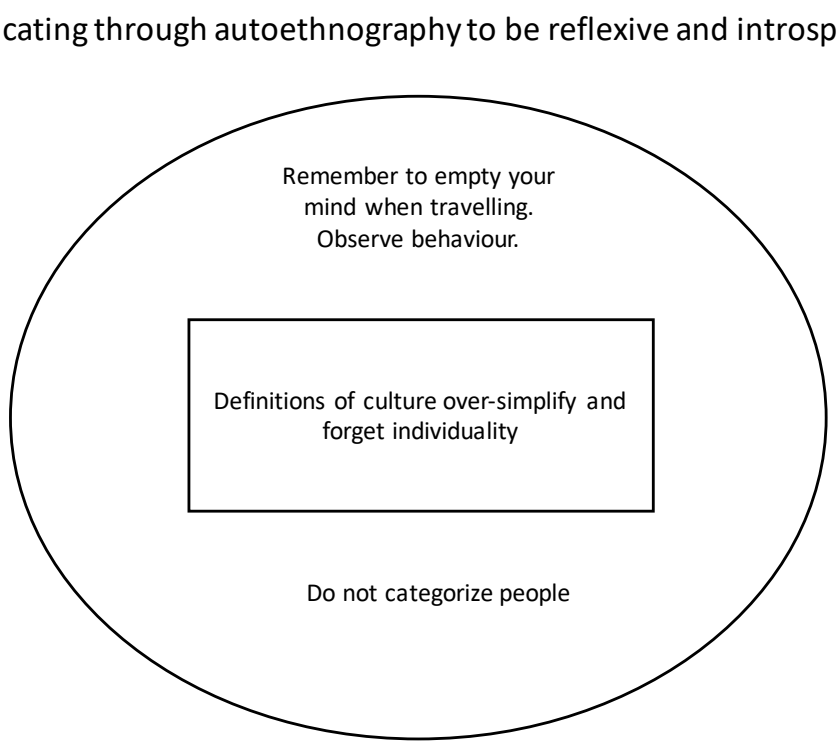

Figure 7. Observe and do not categorize people when travelling.

After writing this study, the author is more aware of his background, culture, and identity. The cultural window, mentioned in Figure 2, may be turned in on oneself. The advice to not categorize people, in Figure 7, may be more significant if one considers one's own self.

In the author's case, being seen as a Portuguese citizen, may be misleading. Having been born in London, in the UK, where he spent his childhood, the author is also English. This, however, is misleading, as the author was brought up in a traditional family by his mother, who is Chinese, but who grew up in Kuala Lumpur, Malaysia. The author's "profile" is perhaps alien to previous categorizations by cultural researchers. Certainly the author has not found a classification of his own

culture; surely, he is a mixture of a number of the cultures mentioned above. If one chooses to add all of his or her experiences together, concerning work, sport, family, travel, personal tragedy, and other difficulties, one notices that categorization is an impossible task. Yet the literature readily categorizes millions of individuals from a country in the same manner. "No one possesses a single culture," warns Handwerker [16] (p. 268). We are all the result of a complex network of relations [16], originating since we were born or perhaps even before that, as our parents raised us as they were taught, and according to what they believe in [4].

If academia is to remain relevant, new research paths and different conclusions need to be arrived at. Only then will humankind progress toward greater unity and collaboration. Should not these be the objectives of higher education, in general? A long path remains to be trodden. Time is of the essence. As the planet suffers, as wars rage on, and as perhaps humanity seems to be lost. Academia is in need of a revolution. Autoethnography may be an important first step in the right direction. We can only hope that this is the case.

6. Autoethnography in Academia: Concluding Remarks

In late 2019, I asked nearly 100 postgraduate students to write their own autoethnographic stories in an essay. I asked: (1) How their group projects had gone and what were the challenges, Was it better working in a group than working alone? How was it to work, in some cases, with foreign Erasmus students? Did group leaders emerge during the assignments? I also asked if and when (2) they were innovative in their personal lives. For this data collection effort, students could choose to sign their work or leave it anonymous. Some students handed their stories to the lecturer in class; others sent them by e-mail. In each case, the students took the exercise seriously, and wrote honest, earnest accounts. For example, one student stated the following, regarding conflict and creativity: "As ideas within a group collide, sometimes arguments ensue that may lead to new brilliant ideas; but, on the other hand, these arguments may condition the development of the project." On the subject of leadership and flexibility, another student stated: "At times, one has to step up to be the leader of the group; at other times, one has to take two steps back and let another element pursue his or her idea just so that he/she may understand that the idea is not plausible."

Through the group work done by students, one may quickly perceive the existence of a deep learning process as important or even more important than the traditional learning that occurs in class. A psychologist and expert on education, Howard Gardner, from the Harvard Graduate School of Education, stated: "I discern two legitimate reasons for undertaking new educational practices. The first reason is that current practices are not actually working. We might think, for example, that we are educating young persons who are literate, or immersed in the arts, or capable in scientific theorizing, or tolerant of immigrants, or skilled in conflict resolution. But if evidence accrues that we are not successful in these pursuits, then we should consider altering our practices . . . or our goals" [32] (p. 10).

I hope to have helped provide an alternative route to education by showing how students can become more aware of the processes in which they are involved in, processes that may lead to long-term behavioral change. What more could we ask of academia? "Education must be lifelong" [32] (p. 9) and what can be more permanent than that which has happened to us? Reflexive introspection is just one path to achieve change in education and it is an important path if followed rigorously and objectively.

Other professionals in the field of education recommend "the type of subjective deep exploration that autoethnography supports. For us, it has functioned as both a methodology and a psychological life support" [29] (p. 741). Clearly, we are not alone in observing an important alternative research method for the social sciences and business studies, in particular.

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Article

The Social Responsibility among Higher Education Students

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Abstract: The aim of this research is to emphasize the importance of education for the philanthropic responsibilities of students. The basic term of the explanatory research is corporate social responsibility, adapted for higher education institutions—the philanthropic responsibilities of students, their implication on charity organization memberships or volunteering activities, and their motivation to help others. Special attention was given to the following questions: Are students involved in charity organization activities or voluntary work? Are there any differences between state and private universities regarding the philanthropic activities of students? How frequently, where, and why are they involved in volunteering? What is the latent structure of students' motivations? The quantitative international survey dates were collected by the Centre for Higher Education Research and Development from Debrecen University, Hungary, and the present examination focuses on the sample from Romania. Using Statistical Package for the Social Sciences (SPSS) statistical software, first, through a longitudinal perspective, Romanian students' implications from state and private institutions were compared. Second, the paper analyzes the characteristics of volunteering and student's motivations. The conclusions present significant differences between state and private institutions. Students traditional motivations, i.e., to help others, were very common and connected with relational and self-development intentions. This mixed motivational factor was different from the global motivational factor (to learn new languages and to discover new cultures).

Keywords: higher education students; social responsibility; private and state institutions; Romania

1. Introduction

The general term of corporate social responsibility has an under-researched dimension—the philanthropic responsibility, or the voluntary contribution to improve the quality life of the community [1]. Adapting this term for an academic context, this paper proposes to study students' implication in charity organization memberships or volunteering activities. These responsibilities constitute an important part on their socialization, their integration into society. Formal education in universities, usually focusing on knowledge, learning performance, or success, neglect the role of out-of-university learning [2]. The education for social responsibilities is a rather new phenomenon in Romania, because it is a post-communist country, where in the last century all private individual or institutional initiatives were stopped for forty years. Today, it has become a necessity to study this topic focusing on the young generation.

The concept of this paper was presented on The European Conference on Educational Research—ECER 2019 Hamburg, Germany.

1.1. Social Responsibility Adapted for Academic Context

Romania is a Central-Eastern state where, since 1948–1949 till 1989, the communist regime quenched independent community activities, and philanthropic NGOs stopped functioning for 40

years. After the democratic change in 1989, the non-profit sector restarted legal activities especially with international support, decreasing after the European Union affiliation in 2007 [3]. Romania, with other post-communist states like Hungary, Slovakia, and the Czech Republic, had a small not-for-profit sector. However, at the same time, Romania has the largest share of private support, measured as the share of non-profit revenues from private philanthropy [4]. The Romanian state neglected to finance the private sector, and internal philanthropic support was insufficient. For this reason, big international NGOs organized projects to bear the social responsibility of the communities [3].

In Romania, in 2010, there were a total of 66,804 NGOs, the biggest numbers functioning on social-charity activities [5]. The first volunteering law was adopted in 2001 and changed in 2014 through the promulgation of the law no. 78/2014. Volunteering is the participation of a volunteer person in activities of public interest carried out for the benefit of other persons or of the community, organized by legal entities of state or NGOs, without remuneration, individually or in groups. It is carried out in areas such as art and culture, sports and recreation, education and research, environmental protection, health, social assistance, religion, civic activism, human rights, humanitarian and/or philanthropic aid, community development, and social development. It is carried out on the basis of a voluntary contract and is the agreement concluded between a volunteer and the host organization, under which the first party commits itself to perform an activity of public interest, without being remunerated, and the second party obliges to offer an activity suitable for the volunteer application or preparation. Voluntary activity is considered professional and/or in the specialty experience, depending on the type of activity, if it is carried out in the field of graduate studies [6].

Charity organizations (philanthropic NGOs) are non-education profile institutions, parts of the non-profit sectors, independent from the state, and altruistic organizations that provide specific social assistance for disadvantaged groups on the community [7]. The social networks of private charity organizations point to the potential benefits of social capital resources in maximizing the positive effects of an educational environment for disadvantaged children [8]. These organizations can be supporting actors in the education of students. Socialization in different communities is a learning process and the norms and the values of these communities have individual and academic benefits [9]. By increasing the implication of students in voluntary activities, the prejudices of people decrease and the cooperation between different ethnically or cultural groups increase [10]. In our society, one negative effect of globalization is the social isolation of children and young people. At the individual level, social immaturity problems are connected with relational un-responsibilities [11,12]. On the other hand, students are not prepared professionals or citizens for the challenges of the technological society [13].

In this paper, the implication of students in charity organizations membership or volunteering activities was connected with the term social responsibility developed especially for a business context. Corporate social responsibility refers to environmental protection and renewable energy development, but on the same time, philanthropic support, social engagement or action too. These are for the benefit of greater society and it can be measured at individual or institutional level. In the social sciences, the external and internal institutional dimensions are more researched than the individual level [14–16].

The theory of corporate social responsibility is based on a Caroll pyramid with four levels: economic, legal, and ethical responsibilities are management's obligations, but philanthropic is more voluntary. Philanthropic responsibilities, at the top level of the pyramid, means a contribution to improve the life of the community. To play by the rules of the game, to be legal is an obligation, but to contribute with resources for the benefit of the community is a voluntary act [1]. Corporate volunteering or employee volunteering means the implication of a company with different activities to improve community life. Corporate volunteering allows workers to work as volunteers during the program, provided with additional material or logistical assistance. This can be realized through the partnerships between companies and non-profit organizations [17].

Figure 1 represents the adaptation of the theory of corporate social responsibility for academic context. The basic student responsibility is the learning goal of the formal education—to participate

and be successful in education process. Concerning ethical responsibilities, universities focus on the micro-ethics of students (the ethical issues of the profession and the research practice), neglecting the organizational, social, legal, and political context. In being taught social responsibility, students will learn the macro-ethical aspect of the work. In this learning process, the connection with external partners is an important step [12]. Students' philanthropic responsibility means volunteer contribution to improve the quality of the life of others belonging to the community.

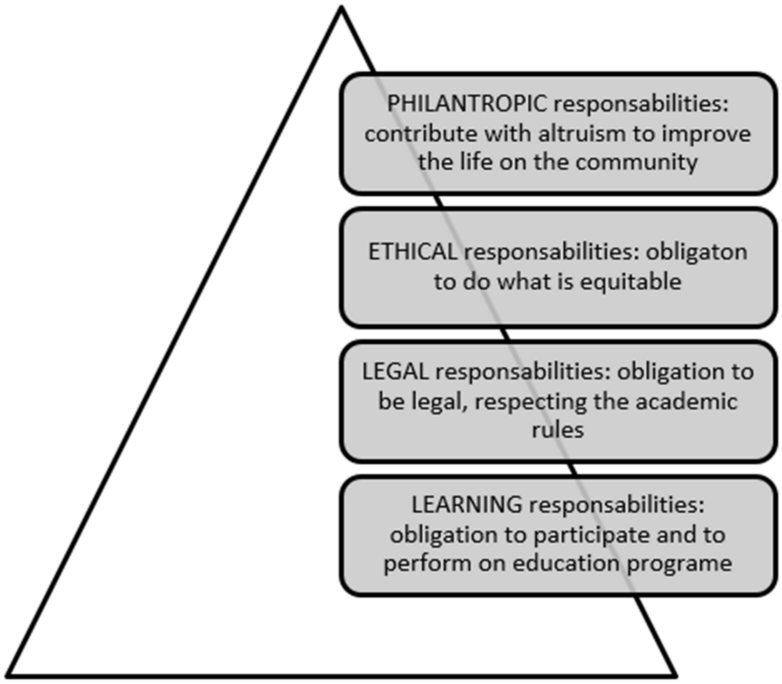

Figure 1. The Caroll pyramid adapted for academic context.

1.2. Students Volunteering Motivations

Starting from the general differences between the formal and non-formal learning, the non-formal education of students take place in institutions out of classes on structured programs where the learning is not evaluated. Students' participation is usually voluntary, and their motivations are more intrinsic comparing with the formal learning motivations (typically extrinsic). The informal, spontaneous learning is present everywhere [2].

This paper also examines the students' volunteering motivations. Ferreira at al. in 2012 identified the following four different categories of volunteers' motivations:

1. Development and learning motivations include motivations connected with their ability to learn or increase self-esteem.
2. Altruism is a behavior for the benefit and welfare of the community, with altruistic motivations "to help others", even with sacrifices. The implication of students on charity organization activities or volunteering can be seen as altruistic behavior act with philanthropic responsibilities.
3. An important category of volunteer's motivations is connected with their need to belong and need to protection, their social and friendship network.
4. Regarding volunteering the less important motivations are related to career recognitions, to improve the CV or to get work experiences [18].

The traditional altruistic motivations constitute a special category and influence the volunteers' intrinsic satisfaction (task consequence) and not specifically the extrinsic satisfaction (action consequence). The intrinsic satisfaction is connected with the opportunity that organizations offer personal development to volunteering students [17].

Earlier country-comparative research results show that, in 2012 and later in 2015, in the cross border region between Hungary and Romania, just a small proportion of students were members on NGOs, volunteering groups, charity organizations or churches. On the other hand, Romanian higher education students were significantly more engaged in volunteering activities than Hungarian or Slovakian peers [19–21]. Analyzing the latent structure of students' civic engagement (memberships on NGOs, volunteering groups, churches, cultural, sport or political commitment), the results of statistical analysis revealed a connection between sport or political organizational affiliation, different from NGOs, volunteering, or faith-based engagements. This result tends either to increase or to decrease the competitive or equitable attitudes of them [22]. Examining the differences between teacher and non-teacher education students' volunteering in Hungarian, Romanian, and Ukrainian higher education institutions, the conclusion was that the type of the education does not significantly influence student's implication [23]. Combining the students' works values and the different types of volunteering, five cluster groups were identified (careerists with postmodern features, unmotivated, highly motivated, volunteers in an anti-volunteering climate and helping new type volunteers) and it has been found that work values and volunteering are significantly connected [21].

This paper aims to create the scientific environment of adapting the theory of corporate responsibility in higher education, where all responsibilities of the students' education: learning, legal, ethical and philanthropic, could be studied in the same context. The universities are competitive institutions with special ethical and legal rules, where the basis of the education is to teach students to perform, and at the same time act legally and ethically within university programs. In the same time, social responsibilities include philanthropic responsibilities, and education in this regard contributes to altruism and improves the life of the community. Non-formal learning through volunteering in charity organizations, and out-of-university responsibilities, are significantly influencing students' socialization and integration in the community, but also contribute to social cohesion, as well.

Starting from the theoretical framework outlined above, the research focus was on the philanthropic dimension of the general concept of corporate social responsibility. Adapting to academic context, the aim of the paper was to study the implication of higher education students in charity membership and volunteering. The research questions were: Are Romanian students involved in charity organization activities or voluntary work? Is there any difference regarding implication of students from state and private universities? How frequently, where, and why are students involved in these activities? What can we conclude about their motivations?

2. Methodological Approach and Student Group Characteristics

The quantitative international survey data used in this analysis was collected and made available by the Centre for Higher Education Research and Development from Debrecen University, Hungary (CHERD-H). This research center leads international projects in the field of higher education in the border regions of Hungary, Romania, and Ukraine (http://cherd.unideb.hu/eng/). The big data bases was collected in 2012 and 2015 by international projects HERD (Higher Education for Social Cohesion Cooperative Research and Development in a Cross-Border Area Project HURO/0901/253/2.2.2.) with case number N = 2728, and by IESA (Institutional Effects on Students' Achievement 2015—Research Application of the University of Debrecen RH/885/2013), N = 2017. The characteristics of these data bases is described officially in [24,25]. The CHERD-H formulates almost the same questions for students regarding civic engagement, starting from 2008, and has partnerships with universities in the cross-border regions [20]. The present research uses the study sample from five Romanian higher education institutions, presented through Table 1, making distinction between state and private sectors.

Table 1. Higher education institutions from Romania included in examination.

Institutions and Locations	Type of the Institution	HERD 2012 N	IESA 2015 N
University of Oradea (Oradea)	state	714	15
Partium Christian University (Oradea)	private	407	40
Emanuel University (Oradea)	private	136	–
Babes - Bolyai University (Cluj & Satu Mare & Odorheiu Secuiesc)	state	66	138
Sapientia University of Transylvania (Cluj & Targu Mures & Miercurea Ciuc)	private	–	126
Totally number of students from Romania		**1323**	**323**

The researched area included the Carpathian Basin, where the language-instruction of institutions was Romanian (University of Oradea and Emanuel University Oradea), Hungarian (Partium Christian University Oradea and Sapientia University of Transylvania) and Babes-Bolyai University from Cluj, which has mixes language-instruction. In 2012, in the subsample were included 714 students from state institutions and 543 from private higher education institutions. In 2015 the number of students from state universities was 153 and from private institutions 166.

Table 2 presents the demographic and academic characteristics of students included in examinations. The investigated population of HERD project in 2012 and IESA project in 2015 were mostly females (the score of males was 373% in 2012 and 16.4% in 2015). Most of the respondents were entry year students at the Bachelor of Science (BSc) level of study, learning in full-time program, financed by the state, and their average age of was approximatively 22 years.

Table 2. The students' demographic and academic characteristics.

Variables	Items	HERD 2012 %	IESA 2015 %
Gender	Male	37.3	16.4
	Female	62.7	83.6
	Totally	100	100
Nationality	Romanian	61.4	5.7
	Hungarian	37.4	91.7
	Roma	0.1	–
	Others	1.1	6.4
	Totally	100	100
Level of the study	BSc	89.1	92.1
	MSc	10.9	7.9
	Totally	100	100
Year of the study	Entered years (1–2)	69.2	81.8
	Close to graduation (3–6)	30.8	18.2
	Totally	100	100
Financed	By the state	57	74.4
	Fee cost	43	25.6
	Totally	100	100
Type of the study	Full-time	99.7	98.5
	Part-time	0.3	1.5
	Totally	100	100

During the examination, it was first presumed that private institution students were much more engaged in volunteering activities and charity organization memberships than students from state institutions. In this part, the focus was on a longitudinal perspective on charity organizations membership and volunteering, comparing state and private students' implication. Second, we exanimated students' motivations in volunteering using SPSS statistical program to compare the

groups (statistical techniques—chi-square test and ANOVA test) and to explore relationships among variables (the techniques of factor analyses) [26].

3. Results

Figure 2 depicts the participation of students' membership in charity groups or organizations in 2012 and 2015, presented as a percentage. We can observe that, in three years, the engagement of students was nearly doubled, and it is important to highlight the big score of students (nearly half of them in 2012 and more than half in 2015) who were not members of charity organizations, but they were willing to become members.

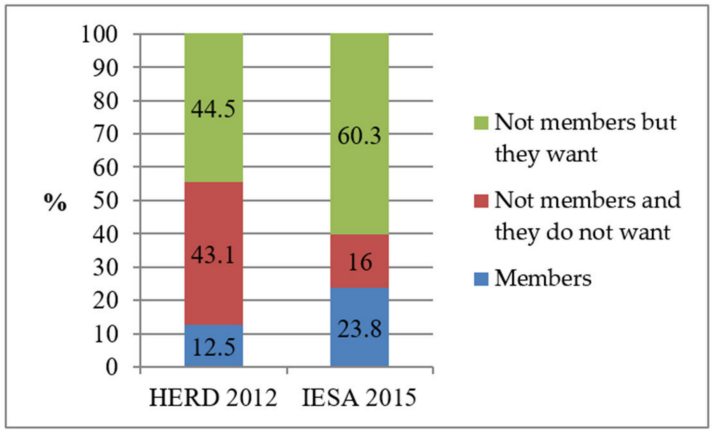

Figure 2. Score for students' engagement in charity membership (%). Source: HERD 2012 (N = 1252) and IESA 2015 (N = 307).

The bar graphs in Figure 3 also suggest an increased score of participation of students in volunteering activities from 2012 till 2015. These figures clearly demonstrate that only 38.8% of students have been involved in volunteering in 2012, but in 2015, the data shows an increased participation up to 57.3%.

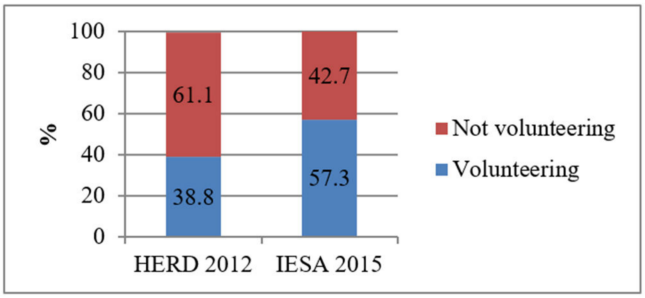

Figure 3. Score of students' volunteering (%). Sources: HERD 2012 (N = 1252) and IESA 2015 (N = 307).

The Table 3 examines statistical significance comparing the charity memberships or volunteering of students from state and private higher education institutions. Using chi-test statistical examination, it can be concluded that the rate of the participation was significantly different in charity memberships in 2012, but not in 2015. Determining the odds ratio, it can be deduced that private institution students had one and a half times better chance to be involved than students from state institutions. The difference between state and private university student engagement was not significant in 2015. To compare the volunteering participation of state and private institution students, the research used the same logic and methodology. The data from Table 3 show that in 2012, students from private institutions were significantly more involved in volunteering than students from state institutions, achieving a highest level of statistical significance (p—Pearson's chi square value is 0.000 and odds ratio

is 1.6). Statistical data revealed also, that in 2015 was an increased score of participation in volunteering activities within students from state institutions (60.4%), where students had a significantly better chance for volunteering than students from private institutions (p value = 0.046 and odds ratio = 0.6).

Table 3. Students' charity memberships and their implication on volunteering from private and state higher education institutions'.

	State (%)	Private (%)	Odds Ratio	Pearson Chi-Square p	N
Charity members in 2012	9.8	**14.4** *	1.5	0.013	1323
Charity members in 2015	23.9	20.5	–	–	321
Volunteering in 2012	32.6	**48.7** ***	1.6	0.000	1257
Volunteering in 2015	**60.4** *	49	0.6	0.046	321

Note: * $p < 0.05$, *** $p < 0.001$. Sources: HERD 2012 (N = 1252) and IESA 2015 (N = 307).

Table 4 outlines the students' volunteering implications in profit or non-profit organizations or in a non-organized way using chi-test statistical examination. The score of volunteering in profit organizations was nearly the same among state and private institution students (11% of the students). The significant differences were shown in preferencing non-profit areas (foundations, associations or churches) and non-organized ways. Students from private institutions preferred to implicate rather in non-profit organization activities than students from state institutions, achieving a highest level of statistical significance (p value = 0.000 and odds ratio = 3.5). In the same time, data revealed the significant preference of volunteering in non-organized ways: students from private higher education institutions were involved in non-organized volunteering with nearly two times higher chance than students from state institutions.

Table 4. The comparison of state and private student's volunteering depending on the type of the organization where the activities were organized.

Where Are You Engaged in Voluntary Works?	State (%)	Private (%)	Odds Ratio	Pearson Chi-Square	N
Profit organizations	11.8	11	–	NS	356
Non-profit organizations, foundations, associations, churches	20.3	**47.1** ***	3.5	0.000	363
Non-organized way	17.2	**28.2** ***	1.9	0.000	363

Note: *** $p < 0.001$, NS—non-significant. Sources: HERD 2012.

A few characteristics of the volunteering are shaped in Table 5. The survey questioned the involvement of students in volunteering during their studies, on a yearly, monthly, or weekly basis. The frequency of the weekly implication was low (just 11–15% of students volunteered every week). Generally, students preferred volunteering on a monthly or yearly basis. Nearly half of them made a connection between volunteering and their study fields, and just a small part of them planed not to volunteer in the future (8% from state institutions and 12% from private institutions).

The final part of the survey made possible the analyses of patterns of the volunteers' motivations. Table 6 lists the possible motivations of students, using traditional (i.e., helping others, protect traditional values), modern (i.e., improve CV, gain work experience), and global reasons (those related to globalization and mobility, see below). The traditional reason for volunteering—namely, to help others—was very common among students (more than 71% of them declared, that this philanthropic motive leads their implications) compared to modern, individual motivations like procuring new experiences, exercising skills or because of possible professional development. It is remarkable that 34% of students were involved because their faith. Modern motivations, such as having these activities in the CV or protecting the environment, were not very common (just 33% of the students choose these options). On volunteering, family patterns or the example of friends inspired just 23% of students.

Table 5. Characteristics of the volunteering and future plans.

Survey Questions	State (%)	Private (%)
How Frequently Were You Engaged in Voluntary Work During Your Studies?		
Never	16	20
Yearly	42	38
Monthly	28	31
Weekly	15	11
Totally	100	100
Is it connected with your study?		
Yes, all the time	11.5	4.3
Mostly	45.9	41.1
Never	42.6	54.6
Totally	100	100
Do you plan to be engaged in voluntary work in future?		
Never	7.9	12.3
Yearly	43.6	52.3
Monthly	38.6	30.3
Weekly	10	5.2
Totally	100	100

Source: IESA 2015 (N = 323).

Table 6. Motivation of Romanian students.

Motivations	%	N
Gaining new experiences, professional development	72.1	261
Exercising my skills	71.2	260
To Help others	71.2	261
Find new relationships, friends	68.1	262
Gaining work experience	68.1	258
For feeling better	63.2	261
Making work relationships	63.2	262
Spending free time usefully	62.2	264
Feeling usefully	59.7	254
To know and understand others	58.6	254
To change my vision about the word	52.0	252
To learn new language	49.2	254
To discover new culture	46.7	258
To change the word	42.4	255
To overcome my problems	38.7	255
To protect the traditional and cultural values	38.4	249
To be appreciated	36.8	253
Because of my faith	34.3	257
To improve my CV	33.5	258
To protect the environment	33.5	253
My friends and family also volunteer	22.9	258

Source: IESA 2015.

Table 7 presents the latent structure of the motivations. Through Varimax rotation, the variables were separated into two factors, showing connections between variables. According to this, the first factor combines both the traditional motivation of helping others with modern motivations—to gain professional or work experiences or exercising skills or motivation for making new relationships and friends. In the second factor the connected variables were related to the globalization and mobility—learning new languages and discovering new cultures. Factors with eigenvalue less than 1.00 were ignored by the computer program. The variance of the first factor, named mixed motivational factor was 36% and the second, named global motivational factor was 22%.

Table 7. The pattern of students' motivations.

Variables	Mixed Motivational Factor	Global Motivational Factor
Professional experiences	0.758	
For new relationships, friends	0.727	
Gaining work experiences	0.714	
Exercising skills	0.653	
To help others	0.594	
To learn new language		0.990
To discover new culture		0.595

Factor analysis: maximum likelihood, Varimax rotation, cumulative explication 58%. Source: IESA 2015.

Finally, analyzing the variance between motivational factors and the type of the study institutions, the independent variable was the type of the institutions (state or private) and dependent variables were the motivational factors. The research question was whether the type of the institution influenced the students' motivations. The difference between the average of the mixed motivational factor and the type of institution (state or private) was significant (F = 7.3 and p = 0.007), and also between the global motivational factor and the type of the institutions (F = 7.8 and p = 0.005). The mean of global motivational factor was higher in private institutions (M = 0.168 and SD = 0.995). The mean of mixed motivational factor was higher in state institutions (M = 0.16, SD = 0.872). However, because the sum of squares was lower than 10 in both situations (6 and 7), the conclusion was that the difference between institution types does not imply a significant difference in the averages.

4. Discussion

This paper exanimated the philanthropic responsibilities of Romanian students from private and state institutions, comparing their implication in charity memberships and volunteering. The motors of volunteering in 2012 were students from private higher education institutions; the statistical analysis shows significant differences between state and private institutions regarding charity memberships and volunteering activities. On the other hand, the longitudinally data revealed the score of increased philanthropic responsibilities in state institutions in 2015. Concerning implication of students from private institutions in 2012 and later, in 2015, there were no remarkable changes, but in the same period, in state institutions, the score was nearly doubled. The explanation should be connected with the amendment of the volunteering legislation in 2014. Adapting to law no. 78/2014, state higher education institutions became potential sources for volunteering and charity activities in the Romanian society.

The hosting organizations of the volunteers were especially NGOs, foundations, associations or churches, but Romanian students preferred also non-organized forms of volunteering. In nearly half of the students, the chosen volunteering area was unrelated to their higher education study fields. Most of them volunteered yearly, and the weekly regular implication was not very common among Romanian students. Most of them plan to undertake voluntary activities in the future.

When analyzing students' motivations, the traditional reason—to help other—was very common. Romania is a country with traditional norms, where the young generation is characterized by closed and rational thinking [27] which reflects in their volunteering motivations as well. These results show a same situation as it is in Hungary, where helping others as motivation was more common among students. Their volunteer implication should be increased through offices, where students can get information about and help finding existing volunteering possibilities [23]. The model of family members regarding volunteering inspired just a quarter part of the students, because the older generation grew up under communist regime and was not used to, even was punished for private initiatives.

The structure analysis of the motivational variables revealed that the initiative to help others was connected with individual and relational motivations (mixed motivational factor) presented in Figure 4. The global motivational factor (related with the global society such as learning new

languages or discovering new culture) had a lower explanatory power on motivation than the mixed motivational factor.

Figure 4. Connections between motivations on volunteering of Romanian students.

5. Conclusions

This paper provides a contextualization of the theory of corporate social responsibility in academic institutions. Learning, legal, ethical, and philanthropic responsibilities should be the direction and content of educating students for social responsibility, in which, besides the competitive nature of learning, the altruism to improve the life of the community is equally present.

The quantitative analysis of this paper focused on the philanthropic responsibilities of Romanian higher education students from private and state institutions, comparing longitudinally their charity organizational memberships and volunteering. First, it was presumed that private institution's students were much more engaged in volunteering activities and charity organization memberships than students from state institutions. This hypothesis proved to be true in 2012, but in 2015, participation in volunteering activities had a significantly increased score at students from state universities. The explanation should be connected with the amendment of the law on Volunteering Activity in Romania in 2014.

The characteristics of volunteering shaped out that Romanian students preferred volunteering on a monthly or yearly basis, especially in NGOs, foundations, associations, or churches, but they preferred non-organized ways. Volunteering was not connected with their study fields for nearly half of the students, and just a small proportion of them did not plan volunteer activities in the future.

Traditional motivation for volunteering, i.e., to help others, was more common among students than learning new language, discovering new culture or protecting the environment as motivation. This willingness could be the basis for universities to facilitate involvement of the young generation in volunteering and charity organization activities for the benefit of the whole community.

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