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Online and Distance Learning during Lockdown Times

COVID-19 Stories (Volume 2)

Edited by
Palitha Edirisingha

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Online and Distance Learning during Lockdown Times: COVID-19 Stories

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Volume 2: Higher Education

Editor

Palitha Edirisingha

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About the Editor

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Palitha Edirisingha is an Associate Professor of Education at the School of Education, University of Leicester, UK. He is a Senior Fellow of the Higher Education Academy.

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He has published on topics related to podcasting, mobile learning, virtual worlds, digital literacy, and open and distance education in developing countries. He conducts learning technology workshops for academic staff and has been involved in developing Open Educational Resources (OERs) for the University of Leicester OER repository.

Palitha is also an editorial board member of the Journal "Interactive Learning Environments". "Trends in Higher Education", and "Journal of Studies and Research on Technological Education". He is a topic board member of the journal "Education Sciences".

Preface to "Online and Distance Learning during Lockdown Times: COVID-19 Stories"

The rapid spread of COVID-19 in early 2020 changed many aspects of society including that of education all over the world. On 11 March 2020, The World Health Organisation declared COVID-19 as a pandemic. Exponential rises in infection rates meant many countries began to introduce public health measures to protect their population. When these were not adequate to control the spread of COVID-19, governments began to introduce ever more severe measures including locking down most areas of social and economic activity. Physical buildings and spaces in schools, colleges, and universities were closed (with some exceptions) too.

Teachers, school leaders and other stakeholders with responsibility for providing education at local and national levels were faced with the unprecedented challenges when providing education without the use of physical classrooms, lecture theatres and laboratories. Teachers and school leaders had several days, if not hours, to prepare to move their teaching online.

The Special Issue published in the journal Education Sciences under the title "Online and Distance Learning during Lockdown Times: COVID-19 Stories" brought together empirical evidence from a diverse range of countries across the world on the use of online, remote, and blended teaching and learning methods across all levels of educational contexts during these unprecedented times.

The present volume is a collection of papers from the Special Issue covering research into teaching and learning in Higher Education (post-secondary) contexts. They represent the international experience of online teaching and learning from the first year of the lockdown, from March 2020 (the start of the first lockdowns in many countries) to about March 2021. These 12 months represent different waves of lockdowns in our authors' national contexts and how teachers and learners had to adapt to the challenging conditions imposed on them during these difficult times.

The first paper in this volume is by Zohra Lassoued and colleagues offering insights on teaching and learning during the pandemic in four countries in the Arab world (Algeria, Egypt, Palestine ad Iraq). Based on data collected using online questionnaires with academics and students during the first wave of lockdown, the authors report the barriers to engagement in teaching and learning activities from pedagogical, technical, organisational, and financial perspectives.

Victoria Abou-Khalil and colleagues' paper also offers an insight into the experience of university students' lockdown learning in low-resource settings in Lebanon. Using Moore's interaction framework as a theoretical model and data collected form students through an online questionnaire, the authors identified a range of strategies students to maintain leaner–content, learner–learner, and learner–teacher engagement. They propose a 10-level guide for engaging students in online learning environments which could have potential uses in education beyond the pandemic.

In the next paper, Marcos García-Alberti and colleagues consider the impact of the pandemic on teaching and learning issues in civil engineering in Spain and Peru. In addition to the research methodology, their paper offers a detailed account of their learning design approach for transforming predominantly practice-oriented subject content and activities for online delivery which might be useful for other practitioners, too. Findings from their study have potential applications for incorporating technologies to leaning opportunities for courses in other STEM areas.

The paper by Sehar un Nisa Hassan and colleagues is based on their research carried out in Saudi Arabia examining undergraduate and postgraduate students' academic self-perception and satisfaction with their online learning during the pandemic. Data were collected using an online questionnaire with 378 students during a semester of online learning. Based on the data from a

majority female student sample (71% of the sample), their findings highlight the range of concerns that students have had during their online learning. Recommendations emerging from the paper would be useful for course designers, teachers, and technical help providers who have had the task of moving from in-person teaching to the online delivery of courses.

In the next paper, Kasiyah Junus and colleagues report the results of their research carried out in Indonesia in which they examined the lecturers' readiness for online teaching as they were required to do so with the closing of physical buildings in universities. The authors were also interested in the obstacles that academics have had to overcome in providing classes online. Using a mixed methods approach involving a sample of university teachers representing all provinces in Indonesia, data were collected on teachers' perspectives at the early stages of lockdown. Results show how teachers adapted to online teaching and various concerns that they had about course design and student learning.

The paper by Ati Suci Dian Martha and colleagues also offers perspectives from Indonesia in which they report students' readiness for online learning. Using a questionnaire as the data collection method (n = 482 from 22 universities), students' leaning experience during the first few weeks of lockdown was explored. The results show the differences in the level of readiness according to the stage of their academic programme (i.e., year of study), academic/subject area of study, e-learning culture of the university, gender, and the region. The study also identifies several barriers to e-learning and offers a set of recommendations for implementing online learning.

The paper of Juan Carlos Mosquera Feijóo and colleagues investigates students' experience in Engineering courses delivered using the flipped classroom model and Open Educational Resources (OERs). Based on data collected from Spain and Peru, the paper provides a detailed account of the learning design involved in developing and delivering teaching, which might be relevant for others who teach similar subjects and who might be considering transforming their courses for online and blended delivery. Based on a survey of students during the one-semester delivery of the modules, the authors highlight the roles of OERs and the effectiveness of the flipped classroom approach.

Engineering is the teaching and learning context of the research reported in the paper by Trina Johnson Kilty and colleagues from the USA. Online teaching during the lockdown periods posed challenges for engineering educators to think about how to deliver practical laboratory-based classes online. Their paper offers findings from a study in which undergraduate university students and a secondary teacher (pre-services) planned a set of lessons for a STEM outreach programme for K-12 students.

Jana Pócsová and colleagues' paper is based on their research into redesigning a mathematics course at a university in Slovakia. The article provides a detailed account of the learning design involved in redesigning the module for online delivery. Based on the data gathered from multiple methods, e.g., students' grades, a questionnaire survey, and analytics from the Virtual Learning Environment, the authors outline their findings on the effectiveness of the online delivery of the maths lessons.

Chris G Lambert and Allan E W Rennie's paper reports the experience from a second year engineering module from a UK university. Based on data collected from academic staff and students on emergency remote teaching and learning using several methods (self-reflection, summative and formative assessments, and student feedback), the paper outlines the challenges that the teachers and course designers faced in making the move from the face to face to online delivery of a module. The paper outlines the variety of ways online delivery engaged students' learning experience as well as challenges with group work and social engagement. Implication for teachers, students and institutions are provided which have the potential for integrating online methods for predominantly

campus-based courses.

The paper by María Teresa Costado Dios and José Carlos Piñero Charlo explored students' perception of their learning experience from a comparative perspective, relating to in person and online learning during the different stages of the pandemic. Based on a descriptive analysis of data from a questionnaire completed by 100 primary education degree students in Spain, the authors identified implications for blended learning approaches as we move beyond the pandemic.

The final paper of this volume is by Arkadiusz Januszewski and Małgorzata Grzeszczak who investigated the challenging circumstances faced by students who undertake internship placements in organisations. These students faced additional challenges due to the lack of organisations that were willing to offer internship opportunities during the pandemic. The authors report their findings from a study on an e-internship initiative. Based on the data collected using questionnaire surveys, they report the students' perception of the effectiveness of the e-internship programme.

The authors in this Special Issue reflected on how educational institutions might need to rethink their teaching and learning provisions as we learn to live with health and other emergencies, such as COVID-19. The knowledge that we can gain from exploring the developments of teaching and learning approaches in many countries and educational contexts in response to the pandemic would be useful for all stakeholders in education in order to reconsider the future of education, and to meet the challenges in the months and possibly years to come.

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Article

An Exploratory Study of the Obstacles for Achieving Quality in Distance Learning during the COVID-19 Pandemic

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Abstract: This study aims to reveal the obstacles to achieving quality in distance learning during the Coronavirus (COVID-19) pandemic and was based on a large sample of professors and students of universities in the Arab world (Algerian, Egyptian, Palestinian, and Iraqi). The primary aim of this research was to investigate the various ways in which students pursued their studies at home during the university suspension as a result of COVID-19. In this paper, the researchers use an exploratory descriptive approach through a questionnaire with a conveniently selected sample of 400 professors and student's returns out of 600 were distributed. The results indicate that the professors and students faced self-imposed obstacles, as well as pedagogical, technical, and financial or organizational obstacles. Recommendations are presented to overcome and understand these obstacles to benefit in the future during unexpected or similar problems.

Keywords: learning barriers obstacles; quality; distance learning; COVID-19 pandemic; questionnaire; professors and students

1. Introduction

Since the World Health Organization declared COVID-19 a pandemic, educators have been forced to shift to online teaching through e-learning systems [1,2]. Al-Araini [3] indicated that distance education is being rapidly adopted, unparalleled in the field of higher education all over the world, bypassing obstacles, problems, and difficulties. Today, higher education institutions face several demands imposed on them by successive scientific and technological developments.

These institutions, despite the limited capabilities and resources available to them, face an increasing demand for higher education and upgrade to the levels of efficiency, effectiveness, and quality, which is not limited to traditional teaching within the classroom.

Higher education institutions must take advantage of developments in communication technology and use them to provide their curricula to those who wish to continue their higher education anytime, anywhere [4]. Sabah [5] summarized the transformations that higher education should undertake to fit with scientific developments, the most prominent of which are the shift from rigidity to flexibility, from the minimum to mastery and quality, from ruminating on information to creativity and innovation, and from limited education to lifelong learning.

The social and technological developments have been accompanied by changes in the field of education, including higher education. Research in the field has documented adaptation and impacts of Information Communication Technologies (ICTs) in higher education over the past three decades, as well as speculating on future trends. Of particular relevance to higher education institutions in

the Arab world is how ICTs and other types of educational technologies may relate to the challenges of massification, since demographic pressures remain high in most Arab countries e.g., Algerian, Egyptian, Palestinian, and Iraqi.

In this regard, Al-Far has referred to future prospects and the form of educational institutions, whereby the role of the university professor at universities and other higher education institutions will diminish, with their role limited to counseling taking place at the level of the group or the individual. The students instead will spend time at the computer using the internet to obtain information from various universities [6].

Efforts and initiatives in the field of integrating technology in the university education and institutions, starting with management, acceptance, and registration processes, and transforming traditional distance education (messaging, radio, and television systems) into electronic or virtual learning on the internet, have led to the emergence of the phenomena of e-Universities and Virtual Universities [7].

To face these challenges and the increasing social demand for higher education, voices have emerged in the Arab world calling for the necessity of introducing methods of distance education and stimulating open education [8]. Distance education is an effective, targeted, and important means of obtaining knowledge and discoveries at the time of their occurrence, to keep pace with the changes of this age and keep pace with its developments at the same time. Societies that do not use the latest methods, capabilities, and methods of distance education have become underdeveloped, and it is difficult for them to coexist in the information era [9].

The philosophy of distance education is based on learner's independence theory, with the least necessary face-to-face interaction with the teacher, and the largest possible amount of individual learning materials, specially produced to simplify learning without contact with the teacher. These include a high degree of quality that is sent using media which permits both individual and group learning with as many learners as possible [10].

Distance education offers educational opportunities for those whose circumstances do not enable them to join formal university education, as teachers and learners are physically separated and interact through modern means of communication [11]. Amidst this deadly pandemic, online platforms, such as video conferencing, online discussions, and free lecture access, are needed.

Internet connections must be good, where instant feedback from students can be achieved and can be used as an alternative to face-to-face classes [12]. Adapting to an online teaching system under crisis is the biggest challenge for teaching and learning solutions that can be made by the institutions to help deal with the pandemic [13].

The Palestinians were the first to establish a university for distance education in the Arab world, Al-Quds Open University. Other Arab initiatives were subsequently announced, including the Open University in Tripoli in Libya, which has many branches in Libyan cities; the University of Continuing Training in Algeria; and the virtual university in Syria. In addition to Egypt's experience in using distance education to train teachers during service, there are preliminary projects for distance education in Yemen, Morocco, Lebanon, and other Arab countries [8].

Some believe that new technologies in developing countries will remain far from the target groups in distance education for many years [14]. Today, with the emergence of the COVID-19 pandemic, governments have been forced to close educational institutions, depriving 89% of learners (i.e., more than 1.5 billion people) in 188 countries from accessing educational institutions [15]. Arab universities are endeavoring to revive the distance education system to continue to provide educational activities for students.

This sudden shift to distance education in an emergency has led to shock and tension among students and faculty members, whether on a personal or professional level, as the process requires extra efforts, in addition to several unusual obstacles for schools and universities such as a lack of time, poor infrastructure, and inadequate digital content [16]. Reliability and the sufficient availability of

technology infrastructure, such as learning tools and digital learning resources in the form of online courses, e-books, and e-notes, are of utmost importance in such a critical situation [17].

Many important parameters that must be considered in adapting to e-learning are instruction, content, motivation, relationships, and mental health, which the educator and the receiver must keep in mind while participating in the system [18]. George [19] in his recent research was concerned about student feedback on distance learning and highlighted the key benefits gained by students for learning during the COVID-19 pandemic. The teaching system in this study was feasible and can be adopted for the lecturing even if not in a pandemic.

Girik [20] investigated perceptions of online learning during the COVID-19 pandemic and the implementation of an online learning system, in which the learners wanted material and assignments to be preceded by explanations, and recommended the use of special media such as Voice Note. His study not only reported that online learning is suitable during the COVID-19 pandemic, but also shed light on the issues of availability of internet access (free), financial issues, and other online learning applications [20].

1.1. Objectives

The present study aims to explore the obstacles to distance learning, from the specific point of view of professors and students in some Arab universities, to benefit those involved in the educational process in the prevention of these obstacles and the success of the distance learning process. Also, to raise questions about the obstacles to achieving high quality in distance learning from the point of view of faculty members of some Arab universities and their students.

This study seeks to:

1. Explore the obstacles faced by Arab university professors and students in achieving quality in distance learning during the COVID-19 pandemic, and understand how these obstacles can be limited from their point of view.
2. Classification and arrangement of these obstacles.
3. Determining the differences in the identified obstacles to achieving quality in distance learning during the COVID-19 pandemic between teachers and students.
4. Presenting some suggestions to overcome these obstacles.

1.2. The Major Questions of This Study

This study's importance stems from the fact that most universities (e.g., Arab universities) have adopted a system of distance education as an alternative to traditional education during the ongoing COVID-19 pandemic, to enable them to complete the lessons and educational activities remaining until the end of the academic year. This situation needs to be investigated to help universities diagnose their status, learn about the difficulties and obstacles that have prevented their success, and find possible solutions to reduce these obstacles.

The main research questions are as follows:

1. What are the obstacles to achieving quality in distance learning during the COVID-19 pandemic from the viewpoint of university professors and their students?
2. In their view, what is the arrangement of these obstacles?
3. Do the obstacles mentioned to achieving quality in distance learning in light of the COVID-19 pandemic differ between teachers and students?

1.3. Importance of This Study

This study seeks to diagnose the reality of distance learning in Arab universities during the COVID-19 pandemic, relying on the opinions of university faculty members and students, as distance learning is a recent trend in many universities. It also reflects the importance of modern technology

and its use in Arab universities that have adopted the system of distance learning to provide university education to the largest number of beneficiaries. The final stage is to come up with results that may help to improve the current use and development of distance education in the Arab region and elsewhere.

1.4. The Limitation of the Study

A large sample was collected after the distribution of questionnaires among a convenient selection of professors and students from different universities as described below:

- Regions: The study included Algerian, Egyptian, Palestinian, and Iraqi universities.
- Period: The study was conducted during April and May 2020.
- Samples: The study included university professors and students.

2. Theoretical Framework and Exploratory Procedures

2.1. Distance Learning

2.1.1. The Concept of Distance Learning

During the COVID-19 pandemic, online education has increased and now makes up a much larger percentage at many universities in China, including overnight shifts of normal classrooms into e-classrooms and adapting to the changing situation [21]. Distance education is an approach to education, not an educational philosophy. That is, students can learn according to what their time allows and in the place that they choose (at home, in the workplace, or in an educational center), and without direct contact with the professor. Hence, technology is an important element in distance education [13].

Distance learning is defined by Holmberg [22] as "a term that includes all methods of study and all levels of education that do not enjoy direct and continuous supervision by teachers attend with their students in traditional classrooms, but the education process is subject to planning, organization, and directed by an educational institution and teachers" [23]. Distance learning is interactive learning between a teacher and a student that takes place outside the walls of the educational institution, so that information and knowledge from its sources reaches the student through technical means and electronic media.

The American Association for Distance Learning (USDLA) defines distance learning as "the process of acquiring knowledge and skills through a variety of media for the transfer of education and information, including all types of technology and various forms of education level for distance learning" [24].

Accordingly, distance learning is an educational situation that requires communication between the teacher and the student through multiple media, like publications, and educational media via modern audio-visual communication technologies. Online learning also can be defined as learning experiences in synchronous or asynchronous environments through different devices and instruments (e.g., mobile phones, tablets, laptops). With internet access, students can be anywhere while they learn and interact with instructors and share their ideas with colleagues [25].

Quality in distance learning is a set of procedures and guidelines established by an educational institution to guide it to manage the organization of its work and providing its services. It requires producing various educational materials, the use of multiple media and activities related to the needs of students, and assessing the needs of the labor market in a way that is compatible with the outputs of the educational process [26].

Obstacles to achieving quality in distance learning are some of the factors that prevent the achievement of quality in the educational learning process according to the distance learning system during the COVID-19 pandemic, which is defined by the professors and students of some Arab universities.

2.1.2. The Distance Learning System

Although focus today lies on distance learning in higher education enabled by the present digital technologies, considering earlier forms of distance learning provides perspectives both on the historical rationales of such education, and suggestions on alternative forms.

Distance learning was historically largely organized to address the needs of adult learners who could not take years away from their professional lives for full time studies at a university. The cost of education was significant for such learners, and for adult learners with families, moving to another town was not always an option. Other reasons for distance education were the need to serve distant rural locations, and in other cases this format was motivated by colonial projects, aiming to gain influence over populations across the world.

The beginning of distance learning as a form of continuous higher education was established in the mid-nineteenth century. A royal agreement for the examination of students studying by correspondence at the University of London was issued in 1896, and in 1858 the university granted degrees to students without the need to attend, followed by other universities. St Andrews University in Scotland had more than a hundred centers around the world in 1877–1931, such as in China and Kenya. The University of South Africa was the first university to introduce an entire distance education system in 1946, and the French National Distance Learning Center (CNED) was established in 1939 [27].

Forms of distance education have become more varied with modern-day technological developments, starting with education by correspondence; then education on radio and television; the use of audio and audiovisual media; the use of the educational phone, interactive video, and the educational computer; to the internet and the progress achieved in the field of education from a distance. The introduction of digital libraries and information systems helped the development of education from its collective form (within the classroom) to the individualization of education and has highlighted the importance of distance learning.

2.1.3. Characteristics of the Distance Learning System

According to Jawda et al. [7], distance learning is considered as a new method of education for so many people, as it adopts methods that are different from those used in the traditional education system. There are many methods used to convey information to learners, instead of relying on one source, as is the case in traditional education e.g., flexibility in acceptance and learning, as the learner can receive his education at anytime, anywhere and expenditure savings, as this type of education is less expensive than other education systems [7].

Among the major disadvantages of ICT-mediated distance learning is about distance learning system that lacks direct interaction and communication between the teacher and the learner, which is currently deficient in providing humanitarian and social expression, and it is unable to provide real expression. The flexibility shown by this system and its acceptance of low grades as a basis in the system is a weak point when compared to the traditional system [7].

Moreover, Jawida et al. [28] added several obstacles that hinder distance learning e.g., staffing shortages and the need for training in the use of the internet by teachers and students and lack of technological infrastructure at universities. Other important points are those related to students where they are living such as the need for access to the safe internet and high-quality-speed internet and specifications, which leads to quickly access data and information. Hence, this leads to secure exchange between the network user and internet service provider specifically during electronic exams (online exam or test) [28].

2.2. Corona Virus Pandemic

2.2.1. Coronavirus

Coronaviruses are a wide range of viruses that may cause disease in animals and humans. It is known that a number of coronaviruses cause human respiratory diseases, the severity of which ranges

from common colds to more severe diseases, especially such as the Middle East Respiratory Syndrome (MERS), and Severe Acute Respiratory Syndrome (SARS), and the newly discovered Coronavirus causes Covid-19 disease [1].

COVID-19 pandemic is a severe acute respiratory syndrome caused by a coronavirus (SARS-CoV-2). In March 2020, the World Health Organization announced that it had categorized COVID-19 as a pandemic [1,29]. COVID-19 is an ongoing global pandemic, discovered during December 2019 in the Chinese city Wuhan.

2.2.2. Corona Disease (Covid-19)

Covid-19 is an infectious disease caused by the last virus that was discovered from the Coronavirus, and there was no knowledge of this new virus and its disease before its outbreak in Wuhan, China, in December 2019, and Covid-19 had mutated now into a pandemic affecting many countries of the world [1].

2.3. Research Approach

This is an exploratory descriptive study that tries to explore a phenomenon in reality and visualize it as it is. The study population was determined by professors and students of some universities from Arab countries (e.g., Algeria, Egypt, Palestine, and Iraq). As seen in (Table 1), it has been sent about 600 questionnaires, a return consisting of 400 professors and students from the total distributed questionnaires that were conveniently selected. The questionnaire was sent to professors and students mostly by email as an online survey method and some of them were personally contacted because they are from the same universities of the authors working place. The high differences between professors and students are because there was a weakness in the response to the measurement tool by faculty members.

Table 1. Distribution of the targeted groups in this study.

Targeted Groups	Total Number	Percentage (%)
University professors	100	25
University students	300	75
Total	400	100

2.4. Study Tool

To find the obstacles to achieving quality in distance learning during the COVID-19 pandemic, the researchers posed an open question to professors and university students, according to which they identified these obstacles. Since the study is exploratory and aimed at identifying constraints, the responses were subject to statistical processing. In the context of preparing a study on "Quality of distance education under the Corona pandemic," please kindly answer the following questions, e.g., in your opinion, what are the obstacles preventing achieving the quality of distance education?

3. Data Collections and Results

3.1. Obstacles Category

The barriers and obstacles to achieving the quality of distance learning under the COVID-19 pandemic, according to the sample, can be categorized into four different groups as shown in (Table 2). The numbers in the column under professor's repetition are the amount of the times for the obstacles that were selected by professors out of total 100 and the next column is the same way for student's selection but out of 300. Overall repetition column is the total number of selection for each obstacle from professors and students together followed by their percentages over total number.

Table 2. Obstacles to achieving the quality of distance learning under the Corona pandemic.

Obstacles Category (Groups)	Obstacles	Professors Repetition (n = 100)	Students Repetition (n = 300)	Overall Repetition (n = 400)	Overall Percentage (%)
Personal obstacles (self-imposed obstacles)	1-The weak motivation of students to distance learning.	65	112	177	44.3
	2-The difficulty of students' understanding of some subjects in the absence of classroom interaction.	60	175	235	58.8
	3-Get used to face-to-face learning.	61	95	156	39
	4-Some professors are not convinced of the usefulness of distance learning.	20	39	59	14.8
	5-Lack of willingness to implement the distance learning system.	69	105	174	43.5
Pedagogical obstacles	1-Difficulty learning some applied courses and remotely oriented work.	18	47	65	16.3
	2-The lack of clarity of the methods of remote evaluation.	47	48	95	23.8
	3-Lack of preparing the university community (administration, professors, etc.) to deal with distance learning.	64	0	64	16
Technical obstacles	1-Weak internet flow (speed).	80	156	236	59
	2-Security and confidentiality of data and information.	66	63	129	32.3
Financial and organizational obstacles	1-The lack of capabilities to communicate remotely (devices, internet, Apps, etc.).	82	155	237	59.3
	2-Lack of training in the use of technology.	71	69	140	35
	3-Multiple electronic media and the absence of uniform controls between all.	52	42	94	23.5
	4-The home environment is not suitable for distance learning.	46	60	106	26.5

An example, the university professors and their students attributed the obstacles to achieving quality in distance learning during the COVID-19 pandemic to the weak motivation of students to distance learning (44.3%), the difficulty of their understanding of some subjects in the absence of class interaction (58.8%), students being more familiar with face-to-face learning (39%), some professors not being convinced of the feasibility of distance learning (14.8%), and everyone is not ready to implement the distance learning system (43.5%). In general, we can observe that the total responses from both sides were much below than 50% (11 out of 14 obstacles) while just three obstacles were above 50%, which means it is a good and positive response for all obstacles.

3.2. Obstacles Arrangement (Ordering)

In Table 3 are the lists of the obstacles according to their percentage value from the exploratory study standing for both professor's and student's overall percentage from 1 to 14 and breakdown percentage showing the similarities and differences between their selection including percentage and order for each obstacle. Also, this has been made to find the breakpoint between the selection of professor's and student's interest. The member's overall percentage of the sample stated that the lack of capabilities to communicate remotely (such as devices, internet, and applications) is one of the biggest obstacles to preventing the achievement of quality in distance learning comes first and the same concern for the professors but different level for the students. In the difficulty of students' understanding of some subjects in the absence of classroom interaction you can see a large gap as breakdown percentage. But in general, from order 9 to 14 you can observe no big difference between professor's and student's overall percentage and breakdown percentage.

Table 3. Arranging obstacles to achieving the quality of distance learning during the COVID-19 pandemic.

Type of Obstacles	Overall Percentage and Arrangement		Breakdown Percentage and Arrangement			
			Professors		Students	
	(%) (n = 400)	Obstacle Order	(%) (n = 100)	Order	(%) (n = 300)	Order
The lack of capabilities to communicate remotely (devices, internet, Apps, etc.).	56.3	1	82	1	51.7	3
Weak internet flow (speed).	59	2	80	2	52	2
The difficulty of students' understanding of some subjects in the absence of classroom interaction.	58.8	3	60	9	58.3	1
The weak motivation of students for distance learning.	44.3	4	65	6	37.3	4
Lack of willingness to implement the distance learning system.	43.5	5	69	4	35	5
Get used to face-to-face learning.	39	6	61	8	31.7	6
Lack of training in the use of technology.	35	7	71	3	23	7
Security and confidentiality of data and information	32.3	8	66	5	21	8
The home environment is not suitable for distance learning.	26.5	9	46	12	20	9
The lack of clarity of the methods of remote evaluation.	23.8	10	47	11	16	10
Multiple electronic media and the absence of uniform controls between all.	23.5	11	52	10	14	12
Difficulty learning some applied courses and remotely oriented work.	16.3	12	18	14	15.7	11
Lack of preparing the university community (administration, professors, etc.) to deal with distance learning.	16	13	64	7	0	14
Some professors are not convinced of the usefulness of distance learning.	14.8	14	20	13	13	13

4. Discussion

E-learning users face many technical difficulties that hinder the teaching and learning system, such as time and location flexibility, students and learners being dissimilar, e-learning not feeling comfortable, increased frustration and confusion, and inadequate technological compatibility [30]. Institutions and organizations should prepare contingency plans to deal with challenges such as pandemics and natural disasters [31]. According to George [32], whether or not there is a crisis, learners need the opportunity to use email-based consultations to approach the course lecturer, as these are the most utilized type of consultation when compared with tutorials (in class) and office-based consultation.

Overall, it was indicated that students' performance was better in classroom-based teaching methodology. However, the above comment from George [33] for online learning only benefits courses with practical components with courses such as English Language and History. COVID-19 has created a problem that has impacted human life and could lead to the global economy shrinking if the restriction of economic activity is extended without an adequate fiscal response [20,34].

In the results of this study, the obstacles to achieving quality in distance learning during the COVID-19 pandemic were limited to four categories, which we explain according to the viewpoint of the individuals of the study sample as follows:

4.1. Personal Obstacles (Self-Imposed Obstacles)

The members of the sample indicated the weak motivation of students to distance learning and the difficulties of their understanding of some subjects in the absence of classroom interaction and direct

(traditional) learning, which indicates their rejection of the distance learning system. Their resistance to it indicates their lack of information and a lack of awareness of its importance in higher education.

E-University courses are implemented in a lecture style, and they are not diversified by modern teaching methods that encourage direct interaction and visual communication between the professors and students. The members of the sample also indicated that some professors are not convinced of the usefulness of distance learning, which is consistent with Alumari et al. [35] regarding the negative perception of some of the faculty members toward e-learning. Some teachers may feel the interest in e-learning frustrated by their belief that it is not important and that it has no value.

This is also in agreement with what is indicated by Hamdan [36] about the lack of sufficient conviction among teachers and students of the importance of distance learning and its multiple advantages. It is supported by the results from Salem [37], who suggested that teachers fear their role in the educational process being reduced, limiting them to becoming educational software designers and educational technology specialists [37]. The lack of willingness of both professors and students to implement distance learning under these circumstances, which confirms their habituation to traditional education learning, means distance education will continue to face resistance. This requires spreading awareness, encouragement, and firmness to accept this change.

4.2. Pedagogical Obstacles

Both professors and students indicated the difficulty of learning some applied courses and directed work remotely, the necessity of the presence of both the professor and the student and direct interaction between them, provided that the professor clarifies and explains this type of course. The lack of clarity in the evaluation methods leads to everyone expecting difficulties in the evaluation of electronic exams.

Furthermore, it is difficult to achieve some pedagogical activities, such as conducting tests, within the e-learning environment, in addition to the difficulty of obtaining feedback for identifying the weaknesses and strengths of students. This may be due to the lack of modern means of communication between students and teachers, especially e-mail and social networks [38]. The failure of the university community (such as the administration and professors) to deal with distance learning, such as by training and preparing electronic courses in advance, the use of modern presentation programs, and other logistical capabilities, have prevented the achievement of quality in distance learning during the COVID-19 pandemic.

4.3. Technical Obstacles

Professors and students indicated that one of the obstacles to achieving quality in distance learning during the COVID-19 pandemic was the weak internet speed in many remote areas, and the consequent interruptions in broadcasting and the impediment to following lessons.

There are also issues with the security and confidentiality of data and information, and protection against piracy on internet sites, which affects the courses and exams and their results, and this is confirmed by the literature [28]. During the performance of electronic exams, the professor cannot guarantee that the student is not trying to cheat, and the professor cannot guarantee that the one who takes the exam is the student himself and not someone else.

4.4. Financial and Organizational Obstacles

A large number of professors and students pointed out the lack of capabilities to communicate remotely, which is consistent with the findings of a previous study about the difficulty of obtaining computers by some students [35]. Also, Alumari et al. [35] indicated the difficulty of dealing with non-cooperative and untrained learners during self-learning and the difficulty of making sure students can master the use of a computer in the absence of computer-trained instructors. The teachers and their students also pointed to the phenomenon of electronic multimedia, and the absence of uniform controls among all professors, which was caused by the new medium and educational strategy. This led to confusion in receiving information, students' difficulty in understanding the lessons. It was clear from

their responses that the home environment is not suitable for distance learning, due to the chaos of children, the narrowness of the house, and the presence of a significant number of learners in the same family with only one computer. All these obstacles prevent the achievement of quality learning from a distance during the COVID-19 pandemic.

4.5. Obstacles Comparisons

Recalling (Tables 2 and 3), both presented a comparison of the answers of professors and students. The differences in the obstacles to achieving quality in distance learning during the COVID-19 pandemic are as follows: 82% of teachers attributed to the lack of capabilities to communicate remotely (devices, internet, applications, etc.), and 80% to weak internet speeds. This compares to 51.7% and 52% of students, respectively. This difference may be because the professors better understand the conditions of their students, particularly the low standard of living in villages and remote areas.

Another observed large difference is that about 71% of teachers attributed the obstacles to achieving quality in distance learning during the COVID-19 pandemic to the lack of prior training in the use of technology, and 66% to the security and confidentiality of data and information. This is much higher than the percentage of students (23% and 21%, respectively). The difference in ratios between the two may be because the teachers were more critical in declaring their weakness in the use of information technology and dealing with applications to give lectures to their students. The lack of a culture of distance learning in Arab societies has made the educational-learning process insecure.

This difference may be because teachers have become accustomed to traditional teaching and have favored it for many years without thinking about diversifying by introducing new methods of e-Learning. The discrepancy between the ratios between the two samples may be due to significant delays in the enrollment of the students in distance education programs, especially those directly broadcast on the internet, and the frequent preoccupation of students and their intensive questioning about how to evaluate them from a distance.

We find that 52% of the teachers considered the multiplicity of electronic media and the absence of uniform controls to be an obstacle compared to 14% for students. The difference in ratios between the two samples may be because the professors differed among themselves in the use of electronic media (platforms, YouTube, television, radio, etc.), which posed difficulties for students.

Finally, about 20% of the professors stated that they were not convinced of the feasibility of distance learning compared to 13% of the students who reported the same answer. The difference in the proportions between the two samples may be because the professors and the university administration did not work on preparing e-courses in anticipation of this unexpected crisis. Their dependence on traditional education requires the presence of the professor in the classroom without the need to provide students with complementary electronic material.

5. Conclusions

Referring to the current situation of the Arab universities, it has combined old and modern forms of distance education, e.g., Algerian, Egyptian, and Palestinian universities that have provided lessons on radio and television. Most Arab universities have used the internet to provide lessons via various educational platforms (such as the Moodle platform adopted by most Algerian universities), or to use social networking sites (such as Facebook and YouTube) to explain the lessons after sending electronic publications through university websites.

Distance learning has become an urgent necessity for higher education institutions, imposed by the nature of emergency conditions in which we live. It is in fact in response to the calling for a modern education system that integrates technology and creates flexibility in the learning environment, to achieve educational security and improve university outcomes. From this study, some suggestions for achieving quality in distance learning for the study area and other areas are proposed as follows:

1. Providing better university infrastructure, by providing computer labs in colleges, and hiring technical supervisors who instruct professors and students on the optimal use of technology, the internet, and various e-learning applications.
2. Preparing electronic courses with a high level of quality, and placing them on university websites for public benefit.
3. Providing continuous training and education opportunities for faculty members in the field of distance education and its requirements, and the new roles that professors and students should take.
4. Diversify distance learning activities to stimulate student motivation and motivate them for self-learning.
5. Coordination of Arab efforts in the field of developing distance education, especially concerning electronic university curricula and remote testing, while respecting overall quality standards.
6. Providing internet access for all students in rural and remote areas.

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Article

Emergency Online Learning in Low-Resource Settings: Effective Student Engagement Strategies

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Abstract: We aim to identify the engagement strategies that higher education students, engaging in emergency online learning in low-resource settings, perceive to be effective. We conducted a sequential mixed-methods study based on Moore's interaction framework for distance education. We administered a questionnaire to 313 students engaging in emergency online learning in low-resource settings to examine their perceptions of different engagement strategies. Our results showed that student–content engagement strategies, e.g., screen sharing, summaries, and class recordings, are perceived as the most effective, closely followed by student–teacher strategies, e.g., Q and A sessions and reminders. Student–student strategies, e.g., group chat and collaborative work, are perceived as the least effective. The perceived effectiveness of engagement strategies varies based on the students' gender and technology access. To support instructors, instructional designers, and researchers, we propose a 10-level guide for engaging students during emergency online classes in low-resource settings.

Keywords: online learning; emergency; low-resource settings; engagement; distance learning; student perception; survey; COVID-19; Moore framework

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1. Introduction

The COVID-19 pandemic forced teachers and students into a sudden transition to emergency online education without prior preparation or guidelines. Faculties rushed to convert their curricula to an online environment, and online pedagogy had to be overlooked [1]. This transition has been particularly challenging and frustrating for students and teachers in developing countries who have access to limited resources [2–4]. Indeed, low internet connectivity, limited access to technology, low resources, and lack of financial support create major barriers that inhibit synchronous interactions and learners' engagement in online education [1,5–8]. This is important because engaging students is essential to reduce their sense of isolation [9] and maintain their desire to learn [10], their satisfaction [11], and their academic achievement [12]. Student engagement even affects the teacher's motivation to teach [13]. A recent study showed an overall decrease of student engagement during online classes provided during the COVID-19 pandemic [14].

Instructors, instructional designers, and system designers need to know which engagement strategies are the most effective in order to engage students in online classes. Previous studies that aimed to extract successful engagement strategies were conducted mainly in developed countries and in online learning contexts that required extensive planning. This is in contrast to emergency remote learning, which does not allow for much preparation

time [15]. It is still unknown which engagement strategies are perceived by students in low-resource settings to be the most effective during emergency online learning; the results may differ from those found in studies of high-resource settings in non-emergency settings. To fill this knowledge gap, we conducted a survey with higher education students who attended emergency online classes in low-resource settings in order to answer the following research questions:

- RQ1: Which engagement strategies are perceived to be the most effective by students taking emergency online classes in low-resource settings?
- RQ2: Is there any relationship between student characteristics and their perceptions of the effectiveness of different engagement strategies?

2. Literature Review

In this work, we examine the engagement strategies that are perceived to be effective by students participating in emergency online learning in low-resource settings. First of all, it is important to clarify the terms that we will be using throughout this paper. When referring to emergency online learning, we refer to education by emergency remote teaching, which is, according to Hodges et al. [15], a "temporary shift of instructional delivery to an alternate delivery mode due to crisis." Accordingly, the objective of teachers providing emergency online teaching is to temporarily instruct in a quick and reliable way, rather than re-create a robust educational ecosystem. In terms of student engagement, there is no one widely accepted definition [16]. In this paper, we adopt Balwant's [17] definition that concludes his review study by defining engagement as the "highly activated and pleasurable emotional, behavioral and cognitive involvement in academic activities." Finally, the term low-resource contexts refer to contexts where (1) the costs of hardware and infrastructure limit access to, and effective use of, technology [18], and (2) an institution's management, instructors, and students have little or no information technology training or expertise. This can be due to a lack of financial resources, a lack of affiliation with larger organizations that could provide such expertise, a geographic location where such expertise is scarce or absent, or a combination of these factors [19]. In the following section, we will first present the framework used in this paper to examine student engagement and provide the rationale behind this choice in relation to the context of emergency online learning in low-resource settings. We will then present strategies that were shown to be effective in engaging students in online learning classes.

2.1. Framework Used in the Study

To maintain engagement in an emergency online learning context, Hodges et al. [15] recommend a careful planning of how to support the interactions that are important to the learning process. One of the major models that defines interactions in distance education is Moore's interaction model, which proposes three interaction categories: student–student, student–teacher, and student–content [20]. Student–student interaction refers to interaction between individual students or among students working in groups. Student–student interaction is desirable for cognitive purposes and motivational support and is particularly threatened in online education as students might not be aware of the identities of students taking the same course [21]. Student–teacher interaction aims to stimulate or maintain students' interest in the content, motivation to learn, and self-direction. Student–content interaction refers to students' interaction with the content that results in a change in their understanding, perspective, or cognitive structure [20]. Through student–content interactions, learners construct meaning, relate the content to previous knowledge, and apply it to problem solving [21].

In this work, we use Moore's model as a framework to analyze students' perspectives of their own engagement in emergency online learning in low-resource contexts. Our choice is motivated by the fact that Moore's model can be applied to a crisis situation and provides the minimal interactions necessary for effective learning while recognizing learning as both a social and cognitive process [15]. Moreover, Moore's interactions represent one

of the more robust bodies of research in distance education [15], and studying student engagement from this perspective allows a comparison with previous work (e.g., [22]) to examine the specificity of strategies needed in emergency online learning and low-resource contexts.

2.2. Student Engagement Strategies

Student–student interaction is viewed as a major element of student engagement, both online and offline [23]. Several student–student interaction strategies are potentially effective in increasing the students' engagement within distance education. For instance, D'Errico et al. [24] showed that using students group chats can increase their engagement. It has also been shown that a collaborative flipped classroom instructional design increases students' engagement as well as their social presence in the course [25,26]. Martin and Bolliger [22] presented student–student interaction strategies that higher education students perceived as moderately important to important. Those strategies include interacting with classmates through presentations, introductions using icebreaker discussions, completing a profile on the Learning Management System (LMS), peer-reviewing classmates' work [27,28], and moderating class discussions. Moreover, Akcaoglu and Lee [29] showed that placing students in small and permanent discussion groups during online classes can increase student–student engagement.

Student–teacher interaction plays an essential role in online learning and has been perceived by students as the most important type of interaction to keep them engaged [22]. Previous research presented several student–teacher interaction strategies that can increase students' engagement. Chen et al. showed that providing a clear set of due dates was perceived as very important for students [30]. This finding was confirmed by Martin and Bolliger [22] who showed that, on average, students perceived this student–teacher strategy as effective. Chen [31] identified five important types of feedback in distance education and showed that the most valued type of feedback is about their self-regulation. Czerkawski and Lyman [23] proposed a framework to foster student engagement in online learning and indicated the importance of instructional feedback. Martin and Bolliger [22] showed that posting announcements or email reminders, using various synchronous features to interact with students and referring to students by name in discussion forums are perceived as effective strategies by students. Anderson and Garrison [32] indicated the importance of instructors' teaching presence in distance education, while Weil et al. [33] pointed out the importance of instructors' presence in online discussion forums.

Student–content interaction is essential for students' independence and self-regulation. Several strategies allow students to interact more effectively with the content and lead to better engagement in online classes. For example, practice tests in online classes are correlated with students' learning satisfaction [30]. However, Poon et al. [34] suggest that it may not be valid to assume that practice tests would be equally effective in the Global South and in limited computing contexts. Multimedia resources have been shown to provide high-level engagement, learner satisfaction, and learning motivation [35,36]. Previous studies showed the importance of instructor-provided summaries in online learning using different means like videos or infographics [33,37,38]. Weil et al. [33] pointed out the importance of case-based learning. Moreover, students perceived the following as effective engagement methods: presenting a topic using a delivery method of their choice, selecting material based on their interests [22], and using online resources to explore topics in greater depth.

3. Materials and Methods

We used a sequential mixed method research design to create a questionnaire and extract the students' perspectives regarding different engagement strategies. First, we conducted a literature review to extract a list of strategies used to engage students in online learning contexts. Second, we interviewed 10 teachers and 10 students to complete the list of engagement strategies with ones used in the specific context of emergency online

learning and low-resources. The list of strategies constituted the building block of the questionnaire, and each strategy's effectiveness was rated by students.

3.1. Literature Review

To identify existing engagement strategies, we conducted a literature review targeting student engagement in higher education. We extracted, as shown in the background section, engagement strategies that were shown to be successful in previous studies. However, we found that the literature only covers engagement strategies used in online learning in high-resource contexts. Therefore, previous literature may lack some strategies that are successful in emergency online learning in low-resource contexts.

3.2. Interviews

As the literature review only covers engagement strategies used in online learning in high-resource contexts, we interviewed 10 higher education teachers and students engaging in emergency online classes in Lebanon to identify additional strategies specific to low-resource emergency learning contexts. The interviewees were selected to obtain a variation sample in terms of age, gender, institution, and courses. The teachers and students had begun emergency online classes at the start of the confinement due to the COVID-19 pandemic and had been suffering from a slow internet connection, limited tools, no previous training, and limited financial support. The interviews explored (1) the challenges they faced and (2) the engagement strategies they thought were effective in facing those challenges. To analyze the content of the interviews, a thematic analysis was carried out following the guidelines of Braun and Clarke [39] by one researcher and reviewed by a second researcher [40]. Each resulting theme corresponded to a different strategy. Our analysis resulted in the following 12 strategies that were not extracted through the literature review: (1) students work in groups on projects using online tools, (2) students prepare for exams together using online communication tools, (3) students work in groups during class, (4) instructor allocates time for questions and answers during the online class, (5) instructor creates a group chat to answer questions about the course, (6) instructor gives students the chance to give feedback, (7) instructor asks questions during the class to verify the understanding of the students, (8) instructor answers queries through their personal contact information, (9) instructor shows their face during the class, (10) instructor shares the screen during the online class, (11) the online class is uploaded on the learning management system, and (12) students take screenshots or video recordings of parts of the class

3.3. Questionnaire Design

The purpose of the questionnaire was to examine the students' perceptions regarding the effectiveness of different engagement strategies, and to identify the individual characteristics that are associated with these perceptions. An initial version of the questionnaire was created, reviewed, and modified by four experts in the field of education, educational technologies, and social informatics. A refined version was pre-tested with two students and further refined. The final version of the questionnaire included 43 questions. It included 11 demographics questions about the student's age, gender, grade, device used to access online classes, experience in taking online classes, major, classes taken online, country of residence, country of the institution, internet speed, and data plan. The questionnaire also included two open-ended questions about (a) the main challenges faced during the emergency online classes and (b) the most effective engagement strategies the student encountered. Finally, the questionnaire included 30 five-point Likert-type items ranging from "1—very ineffective" to "5—very effective" and examining the effectiveness of engagement strategies in terms of student–student interaction, student–teacher interaction, and student–content interaction. The Cronbach's alpha value of the student–student, student–teacher, and student–content subscales are respectively 0.85, 0.89, and 0.87, and exhibited internal consistency.

3.4. Data Collection

The questionnaire was administered online as a Google Form in English and took approximately 15 min to complete. The target study population for the questionnaire was higher education students residing in Lebanon or India or enrolled in institutions in Lebanon or India. The respondents were recruited through faculty members of four universities in Lebanon and one university in India, who forwarded the invitation to participate in the study via email to students engaging in emergency remote learning in their programs. The invitation included information about the study and a link to the online survey. Participation was voluntary and all responses were anonymous. The responses were collected from 26 May 2020 to 31 July 2020.

3.5. Data Analysis

We collected a total number of 320 responses. Seven questionnaires contained missing data and were deleted. In total, 313 valid responses were considered for the data analysis. The respondents' characteristics are shown in Table 1. To understand student perceptions of engagement strategies during emergency online learning, we analyzed the collected data using descriptive statistics. To identify the individual characteristics that are associated with those perceptions, we analyzed the data using parametric inferential statistics, namely a one-way analysis of variance (ANOVA) and Pearson's correlation coefficient. To reveal the gaps of knowledge in the engagement strategies, we analyzed the responses to the open-ended questions using a quantitative content analysis [41,42]. We chose the strategies as a sampling unit and coded the answers to the open-ended question, "What strategies used by the teacher were the most useful?"

Table 1. Summary of respondent characteristics.

	Frequency	Percent
Age		
18–20	162	51.7
21–22	71	22.6
23–25	38	12.1
26–30	28	8.9
>30	14	4.4
Gender		
Female	168	53.7
Male	143	45.7
Prefer not to say	2	0.6
Country of residence		
Lebanon	267	85.3
India	36	11.5
Ivory Coast	6	1.9
Algeria	2	0.6
Democratic Republic of Congo	1	0.3
Canada	1	0.3
Country of the institution		
Lebanon	261	83.4
India	36	11.5
France	16	5.1
Current Education		
Bachelor	205	65.5
Master	83	26.5
MBA	3	1.0
PhD	22	7.0
Major		
Business	165	52.7
Engineering	69	22
Science	35	11.2

Table 1. *Cont.*

	Frequency	Percent
Medicine	26	8.3
Health Sciences	8	2.6
Letters	2	0.6
Social Sciences	2	0.6
Economy	2	0.6
Agriculture	2	0.6
Others	2	0.6
Using Smartphone		
Yes	234	74.8
No	79	25.2
Using PC		
Yes	228	72.8
No	85	27.2
Using tablet		
Yes	106	33.9
No	2017	66.1
Type of connection		
Wifi	188	60.1
3G	53	16.9
Wifi and 3G	72	23
Internet Data per day		
Less than 200 MB	21	6.7
Between 200 MB to 500 MB	47	15.0
Between 500 MB to 1 GB	32	10.2
Between 1 GB and 1.5 GB	55	17.6
Between 1.5 GB and 2 GB	26	8.3
More than 2 GB	47	15.0
N/A	85	27.2

4. Results

4.1. Effectiveness of Student Engagement Strategies

We conducted a one-way ANOVA to compare the differences in means of the perceived effectiveness of different engagement strategies categories as shown in Table 2. The results show a significant difference in the perceived effectiveness of the three categories $F(3, 309) = 71.52$, $p < 0.001$. We also conducted post hoc tests using Tukey HSD and showed that the mean of perceived effectiveness of student–content strategies and student instructor strategies is significantly higher than the mean of perceived effectiveness of student–student engagement strategies.

Table 2. Perceived effectiveness of student engagement strategies.

Engagement Strategy	M	SD	F	Post-Hoc
(a) Student–content engagement strategies	4.04	0.67		a > c
(b) Student–teacher engagement strategies	3.99	0.64	71.52 **	b > c
(c) Student–student engagement strategies	3.45	0.75		

Note. ** $p < 0.001$, Scale ranging from 1 (very ineffective) to 5 (very effective).

4.2. Student–Student Engagement Strategies

Table 3 and Figure 1 show the reported effectiveness of student–student engagement strategies. We conducted a one-way ANOVA to compare the differences in the perceived effectiveness of student–student engagement strategies as shown in Table 3. The results show a significant difference in the perceived effectiveness of the different strategies with $F(9, 303) = 21.72$, $p < 0.001$. We also conducted post hoc tests using Tukey HSD that showed that the perceived effectiveness of using a group chat (Item S1) and collaborating on projects using online tools (Item S2) is significantly higher than the perceived effectiveness of class

groupwork, peer review, icebreaker discussions, and completion of profiles on the LMS. Strategies S1 and S2 were rated either effective or very effective by 61.9% and 62.2% of students respectively. Moreover, students agree that the least effective strategy within all categories is the completion of a student profile on the LMS (Item S10), with only 25.5% of students reporting that the strategy is effective or very effective.

Table 3. Perceived effectiveness of student–student engagement strategies.

Item	M	SD	F	Post-Hoc
S1. Students use group chat to discuss class matters or common interests	3.80	1.11		S1 > S7, S8, S9, S10
S2. Students work in groups on projects using online tools	3.73	1.04		S2 > S7, S8, S9, S10
S3. Students interact with their classmates through presentations in class	3.65	1.12		S3 > S8, S9, S10
S4. Students moderate discussions in class	3.59	1.04		S4 > S8, S9, S10
S5. Students prepare and present lectures together based on their interests	3.57	1.15		S5 > S9, S10
S6. Students prepare for exams together using online communication tools	3.51	1.18	21.72 **	S6 > S9, S10
S7. Students work in groups during class	3.41	1.24		S7 > S9, S10
S8. Students peer-review classmates' work	3.30	1.15		S8 > S10
S9. Students introduce themselves in class using an icebreaker discussion	3.02	1.17		
S10. Students complete a profile accessible to their peers on the LMS	2.88	1.10		
Total	3.45	1.17		

Note. ** $p < 0.001$, Scale ranging from 1 (very ineffective) to 5 (very effective).

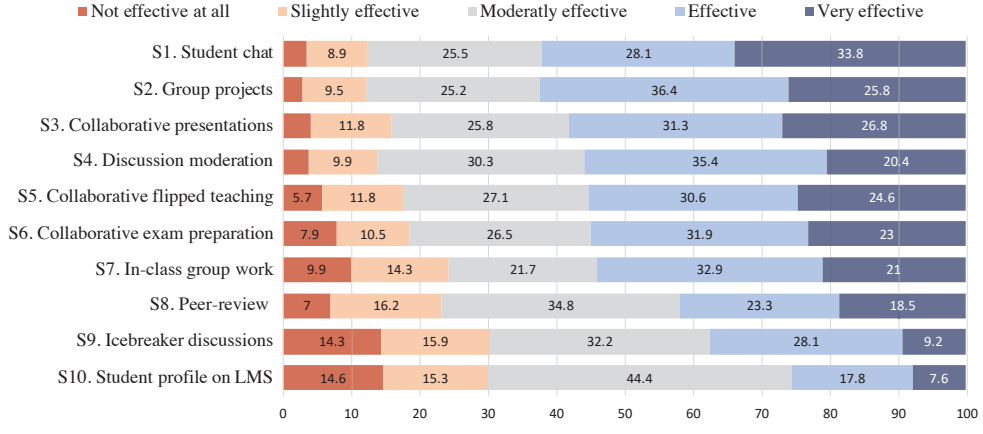

Figure 1. Distribution of respondents' answers for the student–student category.

4.3. Student–Teacher Engagement Strategies

Table 4 and Figure 2 show the reported effectiveness of the student–teacher engagement strategies. We conducted a one-way ANOVA to compare the differences in the perceived effectiveness of student–teacher engagement strategies as shown in Table 4. The results show a significant difference in the perceived effectiveness of the different strategies with $F(9, 303) = 7.31$, $p < 0.001$. We also conducted post hoc tests using Tukey HSD that showed that the perceived effectiveness of allocating time for questions and answers during the online class is perceived significantly more effective than other strategies, with 78.5% of students describing that strategy as effective or very effective. Moreover, posting regular announcements (Item S12), using various features to interact with the students (Item S13), creating a forum/group chat (Item S14), and providing feedback using various modalities (Item S15) are highly rated with more than 70% of respondents describing them as effective or very effective. The least effective student–teacher strategy is showing the instructors' face during the class (M = 3.73, SD = 1.23).

Table 4. Comparison of means of student–teacher engagement strategies.

Item	M	SD	F	Post-Hoc
S11. Instructor allocates time for questions and answers during the online class	4.21	0.94	7.31 **	S11 > S16, S17, S18, S19, S20
S12. Instructor posts regular announcements or email reminders	4.13	0.95		S12 > S18, S19, S20
S13. Instructor uses various features during class to interact with students	4.11	0.94		S13 > S19, S20
S14. Instructor creates a group chat to answer questions about the course	4.11	0.95		S14 > S20
S15. Instructor provides various types of feedback	4.03	0.90		S15 > S20
S16. Instructor gives students the chance to give feedback	3.96	1.04		
S17. Instructor posts a "due date checklist" at the end of each online class	3.90	1.01		
S18. Instructor refers to students by name in discussion forums and during class	3.86	1.01		
S19. Instructor answers queries through their personal contact information	3.86	1.04		
S20. Instructor shows their face during the class	3.73	1.23		
Total	3.99	1.02		

Note. ** $p < 0.001$, Scale ranging from 1 (very ineffective) to 5 (very effective).

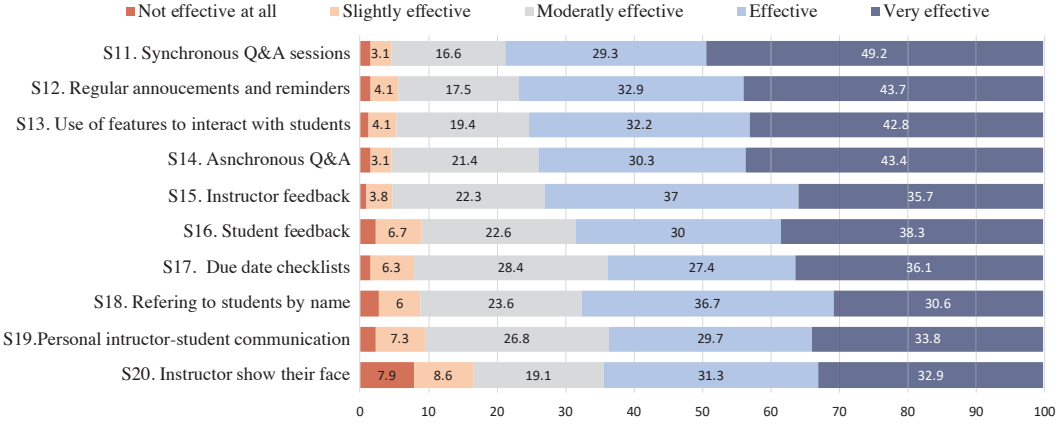

Figure 2. Distribution of respondents' answers for the student–teacher category.

4.4. Student–Content Engagement Strategies

Table 5 and Figure 3 show the reported effectiveness of the student–content engagement strategies. This category is assessed by respondents as the most effective (M = 4.04, SD = 0.67). We conducted a one-way ANOVA to compare the differences in the perceived effectiveness of student–content engagement strategies as shown in Table 4. The results show a significant difference in the perceived effectiveness of the different strategies with $F(9, 303) = 22.39$, $p < 0.001$. We also conducted post hoc tests using Tukey HSD that showed that the perceived effectiveness of screen-sharing during the online class (Item S21) is significantly higher than all other strategies. Moreover, providing summaries (Item S22), uploading the online class on the LMS (Item S23), allowing students to take screenshots and video recordings during class (Item S24), presenting the content in several formats (Item S25), and using tests to check understanding (Item S26), are highly rated by students, with more than 70% reporting those strategies being effective or very effective.

Table 5. Perceived effectiveness of student–content engagement strategies.

Item	M	SD	F	Post-Hoc
S21. The instructor shares the screen during the online class	4.56	0.79	22.39 **	S21 > S22, S23, S24, S25, S26, S27, S28, S29, S30
S22. Summaries are provided at the end of each online class	4.27	0.97		S22 > S26, S27, S28, S29, S30
S23. The online class is uploaded on the learning management system	4.19	1.07		S23 > S26, S27, S28, S29, S30
S24. Students take screenshots or video recordings of parts of the class	4.18	1.01		S24 > S27, S28, S29, S30
S25. The content is presented in several multimedia formats	4.10	1.03		S25 > S29, S30
S26. Instructors provide practice tests to students	3.93	1.02		S26 > S30
S27. Students use online resources to explore topics in more depth	3.92	0.99		
S28. Case-based learning is conducted during class	3.87	0.99		
S29. Students present a topic in a delivery method of their choice	3.74	1.03		
S30. Students select materials based on their interests	3.67	1.01		
Total	4.04	1.02		

Note. ** $p < 0.001$, Scale ranging from 1 (very ineffective) to 5 (very effective).

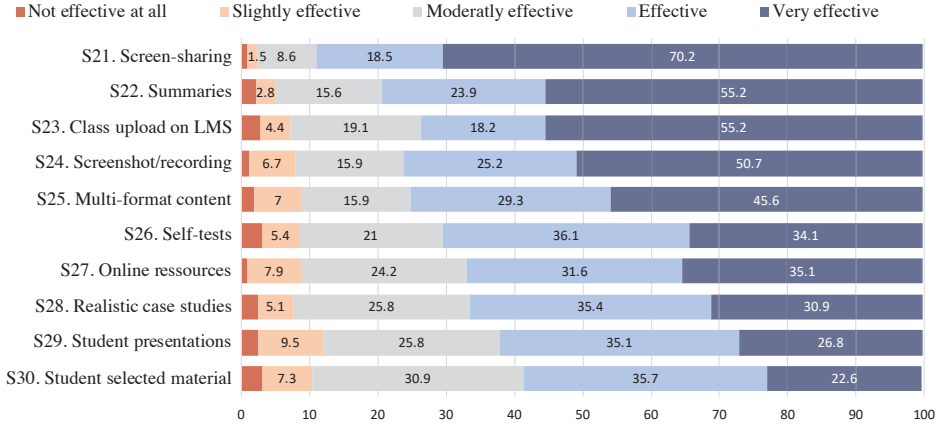

Figure 3. Distribution of respondents' answers for the student–content category.

4.5. Individual Differences

4.5.1. Gender

We conducted a one-way multivariate analysis of variance (MANOVA) to evaluate the differences in gender and perceptions of student engagement categories. The results show a significant difference of means in the perceptions of student engagement strategies with F (6, 616) = 2.12, $p < 0.005$; Wilk's $\Lambda = 0.96$, partial $\eta 2 = 0.02$. We conducted tests of between-subjects effects that showed that gender has a statistically significant effect on the perceptions of student–teacher engagement strategies (F (2, 310) = 4.99; $p < 0.001$; partial $\eta 2 = 0.03$). We conducted Tukey HSD post-hoc tests that showed that mean scores for student–teacher engagement strategies were statistically significantly different between female students and male students ($p < 0.05$), with female students finding student–teacher engagement strategies (M = 4.07, SD = 0.63) more effective compared to male students (M = 3.88, SD = 0.63).

We conducted a series of one-way ANOVA tests to evaluate the differences in gender and perceptions of different student–teacher engagement strategies. The analysis results show that the use of features to interact with students in class (Item S13) was found to be more effective by female students than by male students, F(2, 310) = 3.06, $p = 0.04$. In addition, the creation of a group chat to answer questions (item S14) (M = 3.96, SD = 0.95), F(2, 310) = 4.00, $p = 0.01$; the allocation of time for questions and answers (Item S11)

F(2, 310) = 3.35, p = 0.03; the provision of feedback using various modalities (Item S15) F(2, 310) = 4.04, p = 0.01; and the provision of students with an opportunity to give feedback (Item S16) F(2, 310) = 3.89, p = 0.02 were all perceived as more effective by female than male students.

We also found significant differences between genders regarding two student–content interaction strategies. In fact, female students perceived the presentation of the class content in multiple formats (Item S25) F(2, 310) = 3.59, p = 0.02 more effective than male students. Female students also judged the presentation of content using the delivery method of their choice (Item S29), F(2, 310) = 3.38, p = 0.03 better than male students.

4.5.2. Technology used

We studied the correlations between the technology used (computer, smartphone, or tablet) to attend online classes and the student perceptions of different engagement strategies. We found a weak correlation between the usage of a computer to take online classes and the perception of student–teacher and student–content engagement strategies. The students who were using a computer found more effective student–teacher engagement strategies r(312) = 0.15, p = 0.005, and student–content strategies r(312) = 0.17, p = 0.002, compared to the students who were not. There was no correlation between the use of a smartphone or tablet and student perceptions of different engagement strategies. Consequently, we conducted a one-way MANOVA to evaluate how the use of a computer relates to the perceptions of student engagement categories. The results show a significant difference of means in the perceptions of student engagement strategies with F (3, 309) = 3.59, $p < 0.005$; Wilk's $\Lambda = 0.96$, partial $\eta 2 = 0.03$. We conducted tests of between-subjects effects that showed that technology used has a statistically significant effect on the perceptions of student–teacher engagement strategies (F (1, 311) = 3.21; $p < 0.005$; partial $\eta 2 = 0.02$) and student–content engagement strategies (F (1, 311) = 4.44; $p < 0.005$; partial $\eta 2 = 0.03$). Students who were using a computer found more effective student–content engagement strategies (M = 4.11, SD = 0.59) and student–teacher engagement strategies (M = 4.05, SD = 0.57).

We conducted a series of one-way analysis of variance (ANOVA) tests to evaluate how the use of a computer relates to the perception of engagement strategies. Within the student–teacher strategies, students using a computer perceived the following items as more effective than students not using a computer: the use of various features to interact with students (Item S13), F(1, 311) = 4.38, p = 0.03; the use of group chats to answer questions (Item S14), F(1, 311) = 10.73, p = 0.00; the allocation of time for questions and answers during class (Item S11), F(1, 311) = 10.08, p = 0.00; and the provision of students with an opportunity to give feedback (Item S16), F(1, 311) = 7.57, p = 0.00.

Finally, students using a computer judged the following items as more effective: the instructor sharing their screen (Item S21), F(1, 311) = 30.95, p = 0.00; taking screenshots or screen recordings during the online class (Item S24), F(1, 311) = 4.57, p = 0.03; presenting the content using multiple formats (Item S25) F(1, 311) = 5.22, p = 0.02; working on realistic scenarios to apply content (Item S28) F(1, 311) = 8.95, p = 0.00; and using tests to check their understanding (Item S26), F(1, 311) = 7.39, p = 0.00.

4.5.3. Major

We conducted a one-way MANOVA to evaluate the differences in student major and perceptions of student engagement categories. The major was not significantly related to the perceived effectiveness at $p < 0.05$ with F (27, 879) = 1.07, $p > 0.005$; Wilk's $\Lambda = 0.91$, partial $\eta 2 = 0.031$.

4.5.4. Education level

The education level was not significantly related to perceived effectiveness of different interaction strategies at the $p < 0.05$ level (with student–student strategy F(4, 309) = 0.30,

$p = 0.82$, with student–teacher strategy $F(4, 309) = 0.23$, $p = 0.87$, and with student–content strategy $F(4, 309) = 0.17$, $p = 0.91$).

4.6. Challenges of Emergency Online Learning in Low-Resource Contexts

When answering the question "What are the challenges you faced during the online classes?", the participants reported the challenges shown in Table 6. The most encountered challenges were slow internet connection and frequent disconnections (68%), lack of comprehension and focus (14.6%), and electricity cuts (13.7%). One respondent reported, "The internet connection wasn't fast enough: the teacher's connection is often poor, and we would struggle to understand the course. Connection and electricity cuts were a nuisance on both sides and a waste of time." The main challenges involving student–teacher interaction were a lack of clear schedules, breaks, and explanations. Another student wrote, "Not all teachers respected the pre-established time frames of the courses. They assumed that since we were in quarantine our time was free and set courses in the morning, whereas most of us were still working from home and trying to stick to our usual schedules." Finally, the main problems related to student–content interaction were that STEM classes were difficult to understand (3.5%) and the sessions were not uploaded on the LMS (3.5%).

Table 6. Challenges faced by the participants.

	Frequency	Percent
Student–student interaction challenges		2.5
Difficulty working in groups	4	1.2
Other students are noisy	4	1.2
Student–teacher interaction challenges		
Instructors do not set clear schedules and breaks	13	4.1
Instructors read the material without providing explanations	13	4.1
Instructors are difficult to reach outside of class time	9	2.8
Student–content interaction challenges		
Difficulty understanding STEM classes	11	3.5
The sessions are not uploaded on the LMS	11	3.5
Instructors are difficult to reach outside of class time	9	2.8
Other challenges		
Slow internet connection/disconnections	231	68.0
Lack of comprehension/focus	46	14.6
Electricity cuts	43	13.7
Lack of instructor's IT knowledge	17	5.4
Very long sessions	*15*	4.7
Boredom/low motivation/anxiety	15	*4.7*
Audio quality is very low	11	3.5
Technical problems	9	2.8
Lack of required hardware or software	7	2.2
Technical problems while taking exams online	5	1.5

4.7. Most Effective Engagement Strategy for the Students

When answering the question "Which strategy encountered during the online classes was the most useful to keep you engaged?", the participants presented the strategies shown in Table 7. The strategies included four student–student strategies mentioned 23 times, 15 student–teacher strategies mentioned 88 times, eight student–content strategies mentioned 88 times, and four strategies not belonging to the former categories mentioned 24 times. Moreover, 52 respondents reported not experiencing any successful strategy.

Table 7. Effective engagement strategies according to the participants.

	Frequency	Percent
Student–student strategies		
Students keep their cameras off	12	3.8
Students collaborate on projects	5	1.5
Students are muted	3	0.9
Students discuss the content in groups	3	0.9
Total	*23*	*7.3*
Student–teacher strategies		
Instructor interacts with students during the class	21	6.7
Instructor often repeats main ideas during the class	14	4.4
Instructor responds to students' emails/calls/messages	13	4.1
Instructor allocates time for Q&A during online class	6	1.9
Instructor checks students understanding after disconnection	6	1.9
Instructor calls students by name and asks them to participate	5	1.5
Instructor uses white board feature during online class	4	1.2
Instructor answers questions/sends material over group chat	3	0.9
Instructor uses multimedia when explaining	3	0.9
Instructor summarizes important notions in online class	3	0.9
Instructor answers questions asked through the chat feature	3	0.9
Instructor provides online office hours	2	0.6
Instructor communicates with students through one platform	2	0.6
Instructor shows their face during class	2	0.6
Instructor divides student into smaller groups for Q&A	1	0.3
Total	88	28.1
Student–content strategies		
The lecture is recorded and uploaded on the LMS	43	13.7
The instructor shares their slides during the online class	18	5.7
Explanatory videos explain homework and case studies	7	2.3
Corrections of the exercises are posted on the LMS	6	1.9
Video/slides summaries of the class are provided	6	1.9
Case studies are provided	4	1.2
Self-tests and homework are constantly provided	3	0.9
Exercises are provided during the synchronous class	1	0.3
Total	88	28.1
Other strategies		
Classes are shorter/contain breaks	12	3.8
The instructor uses their mobile data to give the course	7	2.3
The classes are given outside of internet rush hours	3	0.9
Students choose between multiple sessions of the same class	2	0.6
Total	24	7.6
No successful strategies	52	14.3
N/A	45	14.3

The most mentioned strategy belongs to the student–content interaction category: the lecture is recorded and uploaded on the LMS (13.7%). One respondent explained, "Uploading the class on Moodle makes it easier to follow. We don't have to ask the teacher to repeat themselves many times because of the connection issues. We are also able to re-watch the course as many times as needed, the process results in calmer and clearer sessions (better video and audio quality, no disturbances) and we can follow up with our teachers via email or text as we've been doing for any questions we might have."

The student–teacher interaction category contained several strategies that were frequently mentioned. The most frequently mentioned strategy was the instructors' interaction with the students during the synchronous class (6.7%). One student wrote, "Teachers that were very interactive during class and addressed each student were very helpful. Jokes, Q&A sessions, and lots of communication helped me stay motivated." The second most frequently mentioned strategy was the repetition of main ideas during class (4.4%). "It

is useful to repeat the main points during class as some of us might have missed them whenever there's an electricity problem," one student noted.

5. Discussion

We conducted a survey of higher education students taking emergency online classes in low-resource contexts to examine their perceived effectiveness of different engagement strategies. We also examined how different individual characteristics relate to the student perceptions of different engagement strategies. In the following sections, we will discuss our results in relation to the previous literature; based on the results, we will provide a guide to instructors, instructional designers, and instructional design researchers.

5.1. Effective Engagement Strategies

The students perceived student–content engagement strategies as significantly more effective than student–teacher and student–student strategies. Those results differ from previous findings by Martin and Bolliger [22] that showed that higher education students in the United States perceived student–teacher engagement strategies to be the most important of the three categories in non-emergency online learning. This difference could be attributed to the nature of emergency versus non-emergency online learning and/or the resources available to students and teachers in low- versus high-resource contexts. Students in low-resource contexts may have different needs, as total access of the course content can be hindered by a slow internet connection and a lack of required technologies. Content access is placed in the first level of needs of Maslow's hierarchical model adapted to online learning [43,44]. Level two of this model contains pre-course preparation and achievement of a level of comfort with the assigned formats, the online platform, and the instructors' expectations. Only after these needs have been met can the student advance to level three, which is comprised of interactions with students and instructors. Trust and Whalen [45] noted that it is difficult for students in both low- and high-resource contexts to achieve level two in an emergency online learning situation, as instructors and institutions do not have the required level of readiness to provide its criteria.

Students perceived sharing the instructors' screen as the most effective strategy within all categories. This strategy was also mentioned 18 times in answer to an open-ended question regarding the students' preferred strategy. This finding resonates with a recent study showing that during the COVID-19 pandemic, students judged screen sharing as an important feature [46]. Other effective student–content strategies were receiving summaries at the end of the class, accessing the online class on the LMS, and taking screenshots and recordings of the class. These strategies are similar to that of uploading the lecture on the LMS, which was the students' most frequent answer to the open-ended question. The results imply that the students want basic interactions with the content that ensure its effective delivery and availability.

Student–teacher engagement strategies were just behind student–content strategies in terms of perceived effectiveness. According to students, the most effective student–teacher engagement strategies are allocating time for questions and answers during the online class, posting regular announcements, and emailing reminders. The latter strategy was also found to be the most important in online learning by students [22] and teachers [47]. The students' desire for regular announcements and emails could reflect their need for structure and clear requirements, which aligns with the second level of Maslow's hierarchical model applied to online learning [43,44].

Gender and technology used were shown to relate to the perceived effectiveness of different engagement strategies. Female students perceived more effective student–instructor engagement strategies, while science students rated highly student–content engagement strategies. Students using a computer perceived the three categories of engagement strategies as more effective compared to students using phones or smartphones. This may be due to the lack of adaptability of some LMS to mobile devices or the lower cognitive access to video content resulting from mobile-sized screens [48].

5.2. Less Effective Engagement Strategies

Even though the student–content strategies were perceived as the most effective on average, two of those strategies were rated significantly lower than average: (i) students select the material based on the students' interests and (ii) students conduct presentations using the delivery method of their choice. Interestingly, these two strategies are the only student–content strategies that require a mandatory action from the students; they are also the only two strategies in this category that have the word "student" as the subject of the sentence. These results imply that the students prefer that their instructors facilitate their engagement with the content instead of being active participants in the creation of the content. In fact, creating online content requires additional time and effort that students in low-resource contexts might not be able to afford due to a lack of convenient tools and sudden increase in instability. Indeed, our results showed that students with computer access perceived the two above mentioned strategies as more effective compared to students using smartphones or tablets. Moreover, in developing countries, where little or no support was provided by governments, the pandemic created additional time-consuming worries for students regarding their personal finances, future education, or loss of part-time jobs [49] which leaves them with very little extra time.

Additionally, the student–student engagement strategies were perceived as the least effective strategies even though student–student interaction can lead to a sense of belonging and an increased engagement [50]. Martin and Bolliger [22] had similar results and reported that the student–student engagement strategies were perceived as the least important strategies in online learning. However, the average rating of importance/effectiveness varied considerably between their study and ours (3.92 and 3.45, respectively). Martin and Bolliger [22] also found that using a virtual lounge to meet informally was the top strategy in this category, whereas this strategy was rated second to last in our study. Our results also differ from the study by Chen et al. [30] that showed that students taking emergency online classes in the United States felt more engaged during student discussions. A factor contributing to this difference in results could be the cultural background of the students, which affects learning and teaching styles, the goals of the students, and the reasons they put effort into learning [51]. The majority of our study participants are from Lebanon, where an authoritarian style of teaching was still recently the norm [52], and classrooms are teacher-dominated and lack student–student interactions. Moreover, the majority of our respondents are young adults experiencing a pandemic as well as extreme political and financial instability; their reasons for and goals of learning may differ from those of students in other contexts. It is important for instructors and institutions conducting emergency online learning in low-resource contexts to understand their students' goals and motivations and adapt their engagement strategies accordingly.

5.3. Recommendations

Based on the results, we provide a 10-level guide for engaging students in emergency online learning in low-resource contexts. The levels are ordered based on the students' perceptions and are shown in Figure 4. Ideally, instructors and institutions would aim to ensure that the requirements of each level are completed before shifting to the next level. Instructors could also tackle several levels simultaneously while keeping in mind that the upper levels should be prioritized to keep students engaged.

Level	Recommendation	Example strategies
Level 1	Effective delivery of content in synchronous mode	Screen sharing, class summaries, Q&A sessions
Level 2	Engagement with content in asynchronous mode	Materials on the LMS, class recordings on the LMS, reminders and announcements, group chat for Q&A
Level 3	Diversifying means of content provision	Content and interactions in various formats, case studies, online resources
Level 4	Providing and receiving feedback	Feedback from students and feedback for students
Level 5	Continuously clarifying requirements	Practice tests, checklists, and updated due dates
Level 6	Personalizing student-instructor interactions	Reachable for student queries, referring to students by their names
Level 7	Providing a space for student-student interactions	Students group chat
Level 8	Turning students into creators of content	Student presentations, students choose the content, materials, and delivery methods
Level 9	Content-related student-student interactions	Collaborative projects, presentations, exam preparation, moderation of discussion, peer review of work
Level 10	Personal student-student interactions	Ice breaking sessions, students profiles on the LMS

Figure 4. Guide for engaging students during emergency online classes in low-resource contexts.

5.4. Limitations and Future Research

The biggest limitation of the present study is the fact that a substantial portion of the results is based on self-reported perceptions. Self-reporting can be vulnerable to distortions, as respondents may adapt their responses to appear either socially desirable or more distressed than they actually are in order to gain certain benefits [53]. The anonymous aspect of the survey may have reduced any social desirability bias [54]. On the other hand, although we clarified that the survey results would only be used for research purposes, the students may still have tried to appear more distressed than they were to appeal for leniency and indulgence from the involved faculty. To address these limitations, future work could aim to automatically collect data about the students' learning activities to detect engagement (e.g., [55]).

Even though teachers in developing countries are used to low resources, continuous crises, rapid changes, and uncertainties and can rapidly adapt [56], educational planners in emergencies need to consider the effectiveness of student engagement strategies to prioritize interventions. Moreover, the students' socio-economic status affects their access to ICT tools and environments that support their learning [57]. Providing instructors and institutions with equity and poverty education can help them support their students [58] during the fast transition to emergency online learning. To this end, further research is needed to identify how a lack of resources affects students' engagement and capabilities in emergency online learning.

To our knowledge, no previous study examined the effectiveness of engagement strategies during emergency online learning. Moreover, studies on student engagement strategies mostly targeted WEIRD (Western, Educated, Industrialized, Rich, and Democratic) contexts [59]. The importance of this study stems from the focus on emergency learning and previously overlooked contexts. Our study shows a difference between emergency online learning in low-resource contexts and distance education in high-resource contexts. Further research is needed to understand which differences can be attributed to a lack of resources and which can be attributed to the emergency.

6. Conclusions

Our study fills a knowledge gap by providing (1) engagement strategies perceived as effective by students engaging in emergency online learning in low-resource settings, (2) differences in student perceptions of engagement strategies in those contexts based on individual characteristics, and (3) a guide for instructors to engage students in those contexts.

Our study confirms that the student perceptions of the effectiveness of engagement strategies are unique to emergency online learning in low-resource contexts. Our findings suggest that students in those contexts perceive student–content interactions as the most effective, followed by student–teacher and student–student strategies. We also showed that students with different individual characteristics like gender, and access to computers have different perceptions of effective engagement strategies.

To ensure that students' priorities are being met, instructors need to first facilitate an effective interaction between the students and the content in synchronous and asynchronous modes. Once those levels are met, instructors can focus on diversifying means of content delivery, providing and receiving feedback, and continuously clarifying the requirements. The next levels in priority include personalizing student–teacher interactions, providing a space for student–student interactions, and turning students into creators of content. Finally, instructors can encourage student collaborations and personal student contacts to foster student–student interactions.

The results from this study can inform instructors, instructional designers, and system designers who need to design, teach, and support emergency online learning in low-resource contexts.

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Challenges and Experiences of Online Evaluation in Courses of Civil Engineering during the Lockdown Learning Due to the COVID-19 Pandemic

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Abstract: As a consequence of the global health emergency in early 2020, universities had to tackle a sudden shift in their teaching–learning strategies so that the preset competences could be fulfilled. This study presents the learning outcomes of the implemented tasks, student experiences, and feedback, as well as some reflections from the instructors with a holistic perspective of the courses due to the adopted measures and adaptations. Six courses taught at civil engineering degrees of three universities, two from Spain and one from Peru, were analyzed. The teaching and evaluation strategies are described, and some reflections are made by comparing the student's performance with the previous course. Though the shift to online learning had to be made from day to day, with no time for preparation, the experience has proved that online learning can be beneficial in some aspects and has probably come to stay, although some other aspects are difficult to replace with respect to face-to-face learning, especially students' engagement and motivation. The significance of this study relies on a description of the challenges that arose due to the global public health and an assessment of the results of the implemented strategies to account for both teaching and evaluation in modules of civil engineering. After the acquired experience, new questions have arisen, e.g., what type of content is (and what is not) adequate or suitable for online exams? What features have come to stay? Has higher education taken a step forward to tomorrow's education?

Keywords: COVID-19; online learning; higher education; evaluation

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1. Introduction

In the first months of 2020, due to the health emergency triggered by the COVID-19 pandemic at a global level, most educational institutions around the world were forced to modify their teaching methodologies and turn them into new strategies compatible with online learning. Most universities scrambled to adjust and apply digital systems needed for remote learning. However, some recent studies seemed to agree that the teaching institutions were not prepared for such a sudden shift to emergency remote teaching (ERT) [1]. There has been an increasing number of experiences shared around the world studying how this situation has affected teachers and students, especially focused on primary and secondary levels of education [1–4] but not so much at the higher education level [5,6].

In these circumstances, each university adopted different solutions, usually including specific online tools and platforms for distance learning, such as video call applications, and giving general guidelines and instructions so that the lecturers knew how to adapt their teaching activities. Nevertheless, the lecturers were ultimately those who had to make the decision on how to specifically implement online teaching, changing their traditional

teaching strategies by incorporating new tools, such as video calls and screencast videos, and implementing new forms of interaction with the students by using virtual forums or online group tutorials. Thus, the digital tablet has proven to be a valuable tool for teaching and interacting with learners [7–9]. These decisions were made in response to many factors, such as their motivation, digital skills, or family or personal circumstances, all of which could make conciliation harder.

Transforming traditional face-to-face teaching into distance teaching is not trivial, either for the lecturers or students. Some elements must be adapted, such as the teaching materials, the tools used for their production, and the interaction mechanisms with the students. All this implies that both students and lecturers must adapt their daily work, since they must learn how to use new tools and the way they interact with each other.

As Singh et al. stated, the use of the World Wide Web facilitates both types of online learning strategies because it makes asynchronous teaching easier, thus allowing for anytime and anywhere learning, and makes synchronous teaching easier by means of video call tools [10]. Many experiences have shown that online learning is possible using both synchronous and asynchronous methodologies [11,12]. In fact, higher education would be hard to imagine without it, since traditional methods, such as master and practical classes, are often combined with online resources. Nevertheless, evaluation is still not complete because some disciplines, as is the case of many courses in engineering degrees, make use of problems solved in a specific time period as the most appropriate evaluation method, and this is not easy to adapt in an online environment.

During the lockdown period, continuous evaluation techniques were highlighted and recommended. This is a clear trend in the last years, since ongoing evaluation methods are considered to be highly important so that the implementation of corrective actions that help students during the learning process is not done too late [13], but has become particularly emphasized in the period of online teaching due to the COVID-19 crisis. In this regard, some learning methods, such as those involving teamwork, should not be forgotten because these competencies are some of the most demanded in recruitment processes [14–16]. On the one hand, online learning can make this easier, since there are now many collaborative tools that help students to work together; on the other hand, due to the inherent nature of the traditional face-to-face teaching, students are not used to these tools and, as such, could be stressed by the lack of personal interaction on campus, which may make involvement and commitment more difficult. In this field, it is interesting to distinguish between formative and summative assessment [17–19]. Formative assessment is more informal, and its priority is to serve the purpose of promoting students' learning [20] and complementing and helping the more traditional and formal summative assessment based on essays, tests, and exams. Despite its informal nature, or maybe because of it, formative assessment has proven to increase students' achievement [21,22], so it should be boosted, not disregarded, in online environments to promote the engagement and involvement of students.

In this study, the evaluation systems adopted during the lockdown period in six courses taught in three schools of civil engineering were analyzed. These courses were taught by different lecturers using their own strategies and under unequal circumstances. In some cases, the online evaluation was adopted earlier, but in other cases, it was adopted almost at the end of the course, which clearly affected the evaluation methods that were eventually adopted. The evaluation strategies used to suddenly switch from face-to-face to online teaching are presented and discussed in each case.

In the first place, the study is presented, with each of the analyzed courses described. Then, the evaluation strategies adopted in each case are described, and, finally, some results are discussed. Finally, in view of the results, some final remarks and recommendations are given.

2. Description of the Study

This study was built on the shift to remote teaching–learning and assessing in a set of modules taught at three universities under an internationalization scope driven by

the Spanish Ministry of Education [23]. It was part of a collaborative research work on the application of information and communication technologies (ICT) in innovation on higher education. This study shows the impacts of online learning on civil engineering modules of three universities, two from Spain (Universidad Politécnica de Madrid (UPM) and Universidad de Jaén (UJA)) and one from Peru (Universidad de Piura (UDEP)). This allowed for a comparison of results from universities in two countries that, due to heritage and historical reasons, have similar educational systems. Moreover, the Peruvian higher education system has made big efforts in the last few years to be part of a more modern and international group of universities.

The shift to remote training started with the closure of classrooms, which deprived both students and instructors of diverse rights and benefits. On the one hand, it had a negative impact on the inclusion process in higher education, understood as the ongoing and transformative process of improving education systems to meet all learners' needs, especially those of low-achieving students or students with low-income families [24–26]. On the other hand, the change to remote teaching has implied a step forward toward so-called ubiquitous learning [27,28]. Another side effect is the advantage that the university system has taken from such rapid digital adaptation, including the use of pervasive components, e-resources, and online communication technologies amidst the well-known physical constraints to deliver satisfactory and profitable teaching–learning experiences to educational agents. However, this ubiquitous learning model is open for debate and demands further research in terms of both the evaluation of knowledge and behavior change measurement. In this regard, the authors considered that there is room for improvement since a well-tailored integrated teaching–learning environment must comprise online activities, digital materials, and face-to-face interactions to yield satisfactory outcomes.

Table 1 shows the main features of the modules analyzed in this study. All of them formed part of the curricula in civil engineering schools. The subjects hereby mentioned are:

- Universidad Politécnica de Madrid (UPM, Spain): strength of materials, construction management, and dynamic and seismic analysis of structures.
- Universidad de Jaén (UJA, Spain): theory of structures.
- Universidad de Piura (UDEP, Peru): research operations I and II, which are modules completed in consecutive semesters with continuously assessed assignments and exams.

Table 1. Main characteristics of the analyzed modules. UPM: Universidad Politécnica de Madrid; UJA: Universidad de Jaén; UDEP: Universidad de Piura.

Course	University	Degree/Master	Year	Number of Registered Students	Teaching Method	Examination Method
Construction management	UPM	Degree	4th	65	Synchronous	Online
Strength of materials	UPM	Degree	2nd	215	Asynchronous and synchronous	Online
Dynamic and seismic analysis of structures	UPM	Master	2nd	15	Asynchronous and synchronous	Online
Theory of structures	UJA	Degree	2nd	42	Asynchronous	Online
Operations research I	UDEP	Degree	3rd	136	Synchronous	Online
Operations research II	UDEP	Degree	3rd	152	Synchronous	Online

All the courses were adapted to online teaching by means of either asynchronous or synchronous methods. Most classes were taught by means of online video calls. However, some classes for the first two weeks of the lockdown at the UPM and the whole UJA course consisted of screencast videos that could be watched by the students at their own pace.

3. Methodology

The closure of classrooms entailed sudden adjustments on teaching and examinations so that the ongoing courses could end properly. Lecturers had to adapt their strategies to the new context, counting on the available resources in order to comply with the expected learning competencies. Such a big shift involved decisions at several levels, ranging from the rectorate to the lecturers, most of which lacked digital competences and underwent those changes while dealing with the absence of a large variety of individual readiness and capability factors. There is no doubt that these changes have led to a step forward in both the digital transformation of universities and the teaching of the future.

The considered teaching methodologies adopted by the teaching units are presented in this section. The initial strategies planned before the lockdown and the adjustments performed to adapt them to the online learning environment are described.

Likewise, this study gathered the criteria used to assess the impact of this sudden shift on the learning outcomes, as well as on both the instructors' and students' perceptions, which have evolved since then.

3.1. Evaluation Methodology of Courses at UPM

The closure of classrooms occurred some eight weeks after the start of semester. It took between two and three weeks to reconsider and readjust the evaluation strategy since it was mandatory to rewrite such changes in the academic guide.

An important issue was the assessment design, the impact of which on the learning process of students is significant [21,22,29]. Both formative and summative assessments were to be kept: the former as an essential part of the scaffolding structure because students can benefit from the discussion with and feedback from the teacher [30,31], and the latter boosts quality assurance [31].

Two main lines of action were considered upon readjusting the evaluation strategy's tools and resources: (1) the follow-up of students through the continuous evaluation and (2) the preparation of exams.

Firstly, it was essential to keep the instructor's role as both a facilitator and activator of meaningful learning and to help students to take ownership of their progress through ongoing assessment and reflection [32]. Thus, the teaching units approved an increase in the relative weight of the ongoing assessment in the final outcomes.

Class sessions were recorded so that students could access them afterwards. Some supplementary material, and e-resources were made available to students for autonomous learning. In order to ensure a suitable use of the former, diverse short questions were inserted in the pre-recorded videos (Edpuzzle) so that students could only continue watching them after answering. Indeed, this feature was highly valued by them.

In the fundamental degree subjects, students were prompted to solve weekly exercises or problems at home. Additionally, they were made take short online quizzes (Kahoot, Socrative, and Mentimeter) at least once a week during class time.

As with most fourth-year engineering subjects, the construction management module is focused on practical application of engineering knowledge through the relevance of assessments and self-directed inquiry-led learning, which includes visits to work sites. However, during the lockdown, students were prompted to watch some specific documentaries and to analyze the involved processes and workflows. The Edpuzzle has proven to be a valuable tool to insert some short questions at certain stages in order to follow up students' accomplishments.

Regarding the degree and master technologically-oriented subjects, the instructors set several teamwork-based assignments focused on competence-based learning (CBL). In this sense, students should have been capable of demonstrating some specific learning achievements after each stage and before shifting to the next one [33]. Each group worked on an ongoing set of assignments throughout the semester with online presentations on a two-week basis. Such assignments were tailored according to Vygotsky's principle of Zone of Proximal Development [31,34–36], so some questions arose in this regard: what

could they do individually on their own? What could they do with help as they continued to learn by interacting with others around them? The design criteria for such an ongoing, teamwork-based plan built on these features were as follows [37]:

- To tailor the activity with a trade-off between engagement and personal work.
- To build on problem statements that pose relevant challenges.
- To realize that the activities are themselves learning strategies.
- To highlight that the activities are focused on learning rather than on the work product.
- To promote tasks that require thinking and reasoning.
- To focus on the process through appropriate guidelines and instructions.
- To provide students with regular feedback from their progress.
- To assess their learning achievements rather than their work products.
- To empathize with learners when they encounter setbacks along their work.
- To promote a favorable environment that fosters their effort rather than a single task or target.

ICT-based teamwork allows students to develop documentation, reporting, and other transversal skills. Conversely, its implementation requires teachers and students to use a variety of digital tools, highlighting the importance of digital literacy skills [37–39].

Tutorials were another relevant task to follow up and accompany students during the remote learning stage. Those were increasingly given through the online platforms (BlackBoard Collaborate, Microsoft Teams, and Zoom, among others), with noticeably good results, although the online tutorials remained. In this regard, the tablet computer emerged as a key tool to deliver the instructor explanations and responses to students' queries.

Secondly, the civil engineering school ruled that the final degree projects were presented online, and exams were held online as well, which entailed a challenge. This raised a set of obstacles and uncertainties for both instructors and learners: among other issues, some students showed a weak motivation for distance learning and some professors were either reluctant to adapt to distance learning or not convinced of its usefulness, had a lack of preparation for the community to deal with distance learning, or had lack of clarity regarding the methods of remote evaluation.

The instructors involved in this study carried out several online Likert-type surveys among the students to gather their perceptions on the deliveries, the evaluation process, the extent of success achieved from the sudden shift in teaching and evaluation, their learning achievements [40]. The university also conducted end-of-semester surveys to gain insights into students' perceptions on teaching strategies, performance, and the usage of innovative tools in teaching.

Surveys were also intended for understanding the degree of satisfaction with the teaching strategies implemented during the pandemic. The responses were classified according to a Likert scale, ranging from 5 (completely agree) to 1 (completely disagree).

3.2. Evaluation Methodology of Course at UJA

In order to understand why the teaching and evaluation methodology was converted to online teaching, as described later, it must be clarified that the course of theory of structures comprises two main parts. One is an introduction to elasticity, mainly describing strains, stresses, their tensorial expressions, and their relationship through Lamé's and Hooke's equations. The other one is an introduction to strength of materials, presenting axial, shear and bending stresses, torque, and how to solve stress diagrams in isostatic beams. Therefore, this is a course where solving problems has a paramount importance as a teaching tool.

Online teaching due to lockdown started after seven weeks after the start of the semester. From the very beginning, a big effort was made to proceed with the lectures in a way that was as similar as possible to the classroom lectures. Because lectures could not be given in a synchronous way due to family conciliation issues, an asynchronous methodology was followed. Until then, classroom lectures had mainly been given using the blackboard, since, due to the great importance of problems in this course, this is considered

as the most adequate method. Because of this, great effort was made to adapt these lectures to online teaching; thus, lectures were given by means of videos recorded using screencast tools, supported by solved handwritten problems and slide presentations. Problems were solved by hand by the lecturer, and then they were scanned and used to prepare a slide presentation. The progressive explanation that would take place using a blackboard in the classroom was simulated by recording the voice of the lecturer during the slide presentation using the open source software Kazam. Before the lecture, the students had access to the video and the scanned solution of the exercise as a PDF. This material was always available before the official time of the lectures, and clear instructions were given to the students so that they could follow the course and use the material properly. Every two weeks, a group video tutorial session was arranged via Google Meet in order to solve questions and clarify doubts about the lectures, which, together with the doubts solved by email, proved to be an efficient way of solving questions about the course.

Regarding the practical sessions, no big changes had to be made, since all of them consisted of solving given problems by using specific software (MatLab for elasticity problems and robot structural analysis for strength of materials problems) available to the students through academic licenses. Therefore, video tutorials were prepared for instructing the students on the usage of the software, and short videos explained the problems to solve.

Regarding the evaluation of the course, following instructions received from the university, an alternative methodology had to be designed. Table 2 shows how the evaluation methodology was modified to an online final exam by comparing the evaluation items and their weights on the final mark.

Table 2. Modification of the evaluation methodology of the UJA course. The last column corresponds to the modified methodology to adapt the evaluation to an online final exam. Items marked with an asterisk must be passed independently to pass the course.

Item	Criteria	Tool	Weight (Original Methodology)	Weight (Modified Methodology)
Lab practices and use of ICT tools	Participation and attendance, delivery of well solved reports, report structure and quality of the document.	Lecturer's observation and notes. Reports of the practical sessions	10%	30%
Theory and problems	Mastering of the theory and practical aspects of the course.	Final exam	90%	50%
Study of cases and exercises	Works and cases proposed in the practical sessions.	Deliverable problems	0%	20%

The original evaluation system mainly consisted of two items: lab practices that were assessed based on the students' participation and on reports prepared by the students in groups of two members, which had a weight of 10% on the final mark, and a final exam testing theoretical questions and practical problems, which had a weight of 90% on the final mark. Students had to pass both items independently.

The Universidad de Jaén (UJA) decided to switch from a traditional on-site final exam to an online final exam just three weeks before the end of the course and encouraged lecturers to implement ongoing assessment methods to reduce the weight of the final exam. Since this decision was made during the very last part of the course, drastically modifying the evaluation methodology was considered to be unfair for the students, who had been preparing the course based on the original evaluation methodology. In addition to this, including new items at the very last part of the course could have increased their work load in excess. Finally, the assessment methods were adapted following these recommendations while trying to maintain the same general criteria of the original methodology.

It is important to highlight that this course is evaluated mainly using problems that must be solved in a final exam. It is a course in which theory supports the practical part,

but the student must fundamentally learn how to solve problems in a given time. Thus, the evaluation methodology was modified in a way where the same premise was preponderant. A new evaluation item was included "study of cases and exercises," which consisted of problems that were solved in class during the last week of the course. The weight of the lab practices were increased up to 30% to reduce the weight of the final exam, which had a weight of 50% following the recommendations made by the university. The exam maintained the same structure as in a regular year, with a theory part with a weight of 20% and problems with a weight of 80%, but the theory was transformed into an online test and the problems were defined using parameters that had different values for each student (Figure 1 shows an example of one of the problems designed for this exam). Therefore, each student had different results, and copying was not easy. In addition to this, each problem had to be delivered before the next problem was presented, which reduced the chances of sharing results and consultation among peers. To guarantee that the students themselves were the authors of the submitted exercises, prior to the exam, the students were required to send a video showing them writing a specific text by hand in order to serve for comparison.

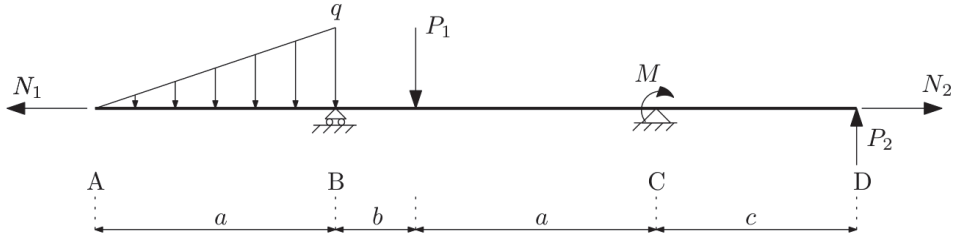

Figure 1. Example of one of the problems designed for the online exam. Each student had a different set of parameters.

Problems were published on the website of the course at a given time, and they had to be solved in paper by hand, scanned with a smartphone, and delivered online before the deadline. Since this procedure was new, the new item, "study of cases and exercises," was designed as preparatory exercises for the final exam so that the students could get accustomed to it. In these exercises, the delivery process was more flexible, since the students were not used to the scanning and uploading procedure, and passing them was not mandatory for passing the course.

3.3. Evaluation Methodology of Courses at UDEP

The two cohorts comprised 136 and 152 registered students, respectively. Lessons were taught remotely and synchronously, and they were simultaneously recorded. Extensive use was made of UDEP Virtual, the digital learning management system (LMS). This platform held a variety of e-resources, often known as e-textbooks, which go beyond electronic versions of printed material since are intended to support both self-paced and tutor-paced student learning [41,42]; these included video conference classes, pre-recorded videos, individual and teamwork assignments, class notes and presentations, podcasts and tutorials.

Such a variety of digital resources was conceived for remote teaching, autonomous learning, and assessment. The coupling of e-textbooks and digital media formed a promising paradigm that could spread higher education to a variety of settings, so that students can be involved in learning contexts with immersive experiences that help them to attain meaningful learning [43]. In this regard, many publishers have made their e-resources free of charge during the confinement period.

Practical lessons consisted of two virtual laboratory sessions and four team workshops, drawing on collaborative work, by using the Excel Solver tool and focusing on competence-based learning [33]. Workgroups were accompanied and supervised by the instructor on a

weekly basis. In addition, students took four individual practical exercises, as well as an end-of-semester exam, for summative assessment issues.

In case students failed to take these exams due to technical, personal, or health causes, UDEP set an extraordinary exams schedule.

This university also conducted end-of-semester Likert-type surveys to grasp students' perceptions on certain features of the course development regarding the impact of innovative tools in teaching and assessment.

4. Results

In order to measure the impact of the experiences described here, a set of indicators for both process and results was applied, focusing on three areas of interest: (1) the impact of e-resources and e-textbooks on learning outcomes, (2) the benefits and drawbacks of online evaluation when compared with on-site sessions, and (3) meaningful learning achievements.

The impact of the whole evaluation process raised several reflections from both the instructors' and students' standpoints.

Most students expressed diverse concerns about the new constraints:

- Weak motivation for distance learning; the home environment was not suitable.
- A shortfall in their comprehension of some applied subjects in the absence of classroom interaction.
- Difficulties when performing remotely oriented work.
- Uncertainty about the lack of clarity of the methods of remote evaluation.

Regarding the professors, the following reflections can be summarized:

- The need to overcome an initial resistance to adapt to remote education.
- Online teaching requires a big effort in preparing new material, although it can be used again in future courses.
- Lack of digital competences in professors.
- Lack of preparing the university educational agents to deal with distance evaluation.
- Lack of training in the use of technology and the absence of uniform controls among all exam takers.
- Some instructors are not yet convinced of the usefulness of distance learning and assessing.

Some difficulties and uncertainties drove the at-hand preparation of exams:

- To maintain the preset learning competences and outcomes.
- To ensure honesty, probity, confidentiality, authorship and equal opportunities of the exam takers.
- The possibility of designing exams while keeping the same structure as in the on-site ones.
- The online examination tool could not be a source of uncertainty nor conflict to students.
- It was mandatory to avoid third-party tools or resources by the exam takers.

Hence, the exam setting estimated very tight response times: questions and problems were precise and objective so that the response resulted from reasoning, relating concepts, and demonstrating, arguing, or deriving arguments and expressions. Thus, the design of exams became a trade-off between keeping the as much of the original classical structure as possible and remaining ethical and ensuring authorship issues. However, our ex-post analysis showed that the instructors' primarily focused on avoiding cheating. As a consequence, low-achieving students were especially affected by such measures. Nevertheless, the figures of both passing students and dropouts were similar to those of the previous year. Therefore, it cannot be concluded that the sudden shift to remote learning had an impact on the outcomes. Indeed, students' feedback confirmed this conclusion.

Table 3 shows a comparison of both passing and dropout rates between 2019 and 2020 for the selected modules. As the differences were not significant, we cannot conclude any kind of impact in those outcomes from the change to remote teaching.

Table 3. Comparison of students' performance in each course in 2019 (face-to-face teaching) and 2020 (online teaching).

	Registered Students 2020	Passing Rate 2020 %	Dropout Rate 2020 %	Passing Rate 2019 %	Dropout Rate 2019 %
Strength of materials	215	42	27	60	22
Construction management	65	75	11	73	8
Dynamic and seismic analysis of structures	15	100	0	91	9
Theory of structures	42	50	19	44	22
Research operations I	136	97	5	84	16
Research operations II	152	98	1	84	12

In general, the response and attitude of students to online exams were notably positive and proactive. Most of them acted responsibly, were eager to participate, and reached their learning outcomes. However, around 10% of exam takers lacked maturity as they tried to cheat and exchange information during the exams. Given that most students were actually proficient in digital technologies, instructors struggled to monitor the exam sessions, even with online video surveillance. Additionally, students at home were prompted to write the responses to the question in their own hand, scan their manuscripts, and upload the resulting PDF files to the examination platform.

The figures of grades, dropouts, and their ratios compared with the previous year's numbers, among other figures, are valuable objective indicators of learning outcomes. Some of the available data are issued by the universities since they form part of the information submitted to the respective national certification agencies [15,16]. This study only compared learning outcomes from these last two years since these teaching units applied the same methodology with the same instructors, syllabi, and university policies.

4.1. Results of Courses at UPM

The previously described process and behavior patterns applied to this case. Regarding the concern about the security and confidentiality of data and information during exams, one noticeable proof of cheating is shown below. Three exam takers wrote the response to a given exercise in their own hand and uploaded the scanned versions to the platform. All three used the same alternate approach to address the solution. However, such a method neither belonged to the module syllabus nor was taught by the instructors. Additionally, all three students depicted the same charts and schemes with the same mistakes indeed at the same steps. Figure 2 shows the excerpts from the three individual responses.

Student experiences and feedback revealed rather good acceptance and goal achievement, as shown below.

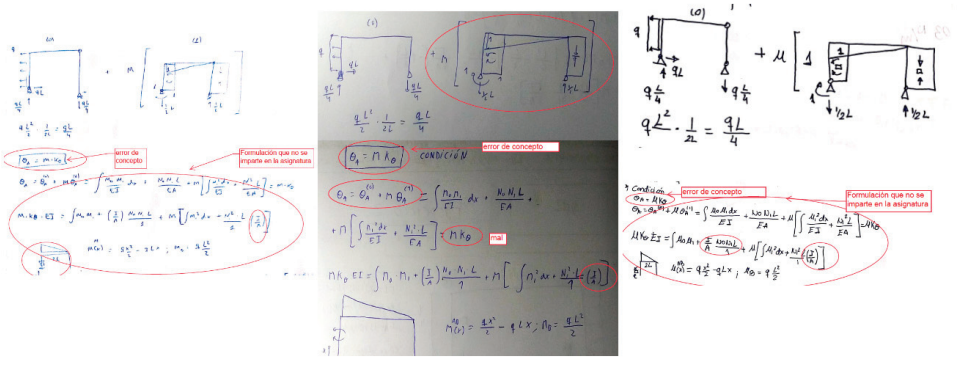

Figure 2. The same excerpts from three students' own manuscripts during a remote exam. The approach, notation, and procedure was the same in all three cases and not taught in the course. Even the mistakes coincided and were at identical places.

4.1.1. Strength of Materials and Construction Management

The items of interest were the following:

1. Degree of satisfaction with online classes.
2. How do you value your learning of the subject when compared with face-to-face classes?
3. Have you studied autonomously the subject more than during in-person period?
4. Degree of satisfaction with individual time management and learning.
5. How could you study in online groups during the pandemic as compared with the on-site regime?
6. How do you value your learning achieved through studying in groups during the pandemic?
7. Degree of satisfaction with the e-resources delivered by the instructors of the subject during the lockdown period.
8. Certainty on having mastered the two key concepts taught in the subject.
9. Would you recommend applying the teaching method used in this subject to other modules?
10. Have you achieved the learning expectancies during this period?
11. Your degree of readiness to follow online classes at the beginning of the lockdown period.
12. Your current readiness to follow online classes at the end of the lockdown period.
13. Degree of mind shift with respect to online classes after this experience.
14. Open questions, suggestions, complaints, etc.

Students expressed a fair acceptance of the digital resources involved during the distance learning stage, as well as a reasonably good achievement in their goals. Their suggestions helped to design future actions for the next course, regardless of whether it is online or on-site.

4.1.2. Dynamic and Seismic Analysis of Structures

The remotely oriented teamwork was weighted as one third of the final grade. It was conceived for competence-based learning focused on problem solving. Thus, the survey included three main topics: the fulfilment of learning achievements, perception of teamwork effectiveness, and perception of team leadership. Several items were about the individual learning achievements within the group work method. The main questions were:

1. I have mastered the core concepts application to the seismic design of a given simple structure.
2. Satisfaction level with individual learning from teamwork
3. Satisfaction level with autonomous learning and individual contribution to teamwork

4. Would you recommend applying competency-based learning through teamwork to other modules?
5. Have you achieved your learning expectancies during this period?
6. Your readiness to do online teamwork in the beginning of the lockdown period.
7. Your readiness to do online teamwork at the end of the lockdown period.
8. Level of satisfaction with your own contribution to teamwork
9. Level of satisfaction with teammates' contribution to teamwork
10. Extent of mind shift with respect to teamwork benefits after this experience.
11. Own leadership skills for doing teamwork.
12. Own skills for overcoming setbacks collaboratively.
13. Team leader's skills for overcoming setbacks collaboratively.

4.2. Results of Course at UJA

Figure 3 shows a correlation between the final mark of a student and the average time he or she took to view the PDF files prepared for every lecture since they were available online. This graph is intended to show that there was a connection between both values because it was expected that a motivated student would visualize the available material earlier than a non-motivated student, since the former would usually prepare for the course at the same rhythm it is taught and the latter would procrastinate and only study during the last few weeks before the final exam. Each mark represents a student, and the dashed line shows the linear trend of this correlation. It shows a decreasing trend, as expected. Data are broadly spread around the first part of the graph, which groups those students that visualized the files earlier, which is logical because not all students had the same capacities and not all of them needed the same time to comprehend the concepts. Nevertheless, it is clear that a significant delay in accessing the material was related to a lower final mark.

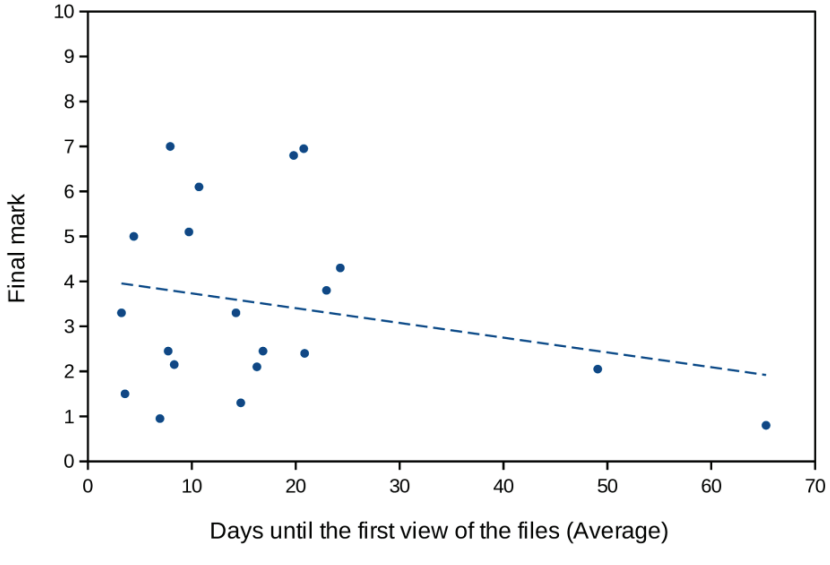

Figure 3. Correlation between the final mark of the students and the average time they took to access the PDF files available for each lecture. The dashed line represents the linear trend of this correlation.

In addition to this conclusion, it was interesting to analyze some aspects observed during the online teaching period. Since the students had access to the videos and the scanned solution of the problems at the same time, they could only focus on understanding the video and taking notes of those issues that were of particular interest for them. Since the problems were solved by using a slide presentation, the explanation time was reduced

(a traditional lecture of 50 min was reduced, on average, to 35 min), since no time for writing on a blackboard was required. This, in a traditional classroom teaching context, can be seen as a drawback because a faster pace of teaching may become elusive for some students, but in this online context, it proved to be beneficial. Since lectures were recorded in videos that were accessible to the students any time and as many times as they wanted, those students who needed to could easily rewatch the whole video or only certain parts, but those students who did not need to had more time available for other subjects. In this regard, the students expressed their satisfaction with this teaching methodology during the group tutorial sessions, remarking on the convenience of watching the lectures more than once if they needed. This supports, as already stated by Shahabadi and Uplane [44], that anywhere–anytime learning has clear benefits for students because they have control over their learning pace and can manage their time better.

Regarding the practical sessions, they seemed to be efficient, and, compared with previous years, no big problems were encountered. By contrast, solving questions from the students became a much more time-demanding task because, due to the extraordinary situation motivated by the lockdown, students were allowed to ask questions via email or ask for video calls with the lecturer. This led to a situation where the lecturer's availability was not limited to specific time periods during the week, instead being extended to the whole week. This proved to be effective for solving questions but implied a high additional workload for the lecturer.

Figure 4 shows the students' performance compared with the previous year. It is interesting to observe that, although an online exam could imply higher rates of cheating leading to better marks, this was not the case. In general, almost no cheating was detected, and the design of the online exam—with different parameters set for each student and a sequential solving of the problems—seemed to be a successful alternative to the original classroom exam, with similar problems and difficulty.

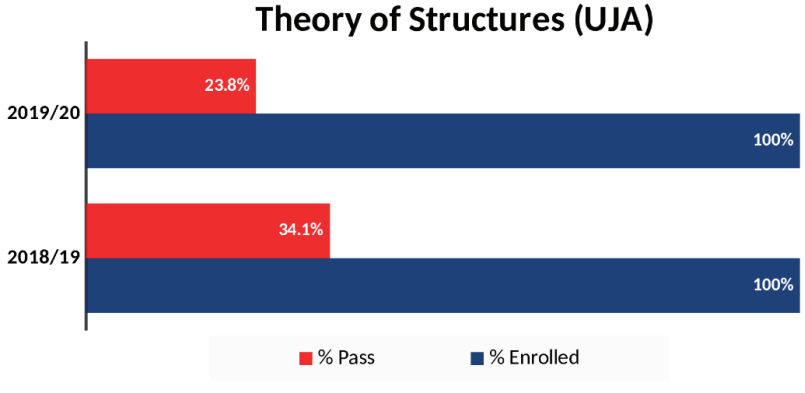

Figure 4. Comparison between the students' performance of 2018–2019 and 2019–2020 courses for theory of structures, taught at UJA.

It must be noted that the lower performance of the students with respect to the previous year cannot be attributed to the adopted online methodology, since the same methodology was used in another course taught in the mechanical engineering degree at UJA, and the performance there was higher (from 32.6% in 2018–2019 to 59.4% in 2019–2020). For some reason, the students of theory of structures were less motivated during the semester. Some of them mentioned that the workload of deliverable reports in other courses had remarkably increased because shifting to online evaluation had encouraged other lecturers to reduce the weight of the final exam and increase the number of ongoing evaluation tasks.

4.3. Results of Course at UDEP

In short, features inquired by the questionnaire were:

1. Degree of satisfaction with the implemented remote teaching model.
2. Degree of mind shift with respect to online classes after this experience.
3. Degree of accomplishment of the module syllabus.
4. Assessment of the implemented evaluation methodology.
5. Usefulness of the virtual lab and workshops.
6. Instructor availability.
7. Usage of innovative resources and e-textbooks in remote teaching.
8. Usage of digital resources and e-textbooks in assignments and exams.
9. Teacher–student interaction and availability to deal with unforeseen events.
10. Adequacy of elapsed time for grade publishing.

4.3.1. Research Operations I

Pass rate was 97% of the 136 registered students. Their level of satisfaction with the implemented online teaching and assessing approaches suggested a line of action for next year's courses.

Figures 5 and 6 show the average levels of learners' satisfaction about the two modules, whereas the red lines show those of the engineering faculty.

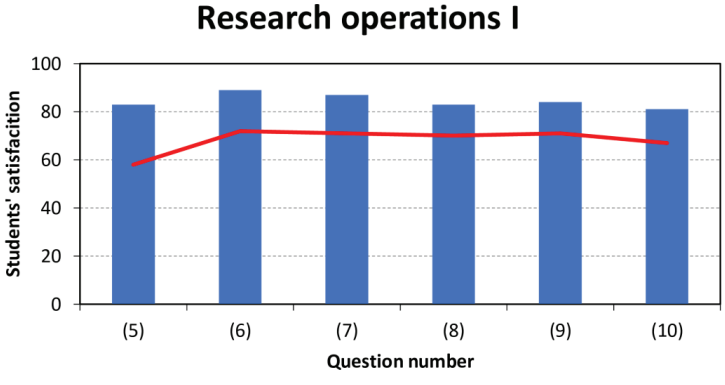

Figure 5. Average values of UDEP students' satisfaction degree regarding the teaching–learning and assessment processes in research operations I.

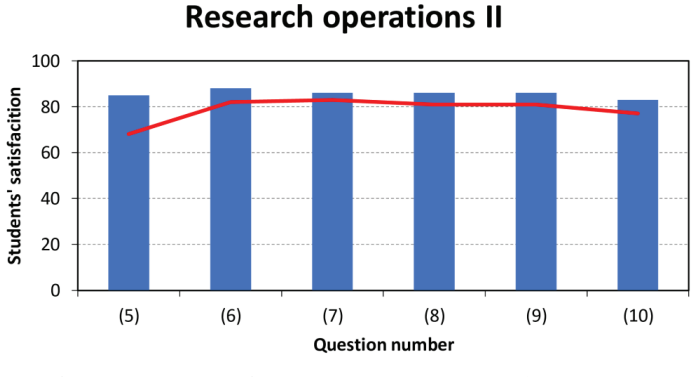

Figure 6. Average values of UDEP students' satisfaction degree regarding the teaching–learning and assessment processes in research operations II.

4.3.2. Research Operations II

The enrolled group comprised 152 attendees. The feedback from the survey on their perceptions and degree of fulfilment of expectancies is summarized below.

Learners individually took four practical virtual lab exercises, as well as an end-of-semester exam, through Zoom. Instructors faced analogous difficulties and issues regarding probity, individuality, and authorship. Around 6% of students failed to take the ordinary evaluation items and dates, mainly due to personal, health, or technical reasons. Thus, the university arranged an extra-ordinary call for the "COVID exam".

5. Discussion

University students in both countries lead technologically-focused lives, as they are, arguably, digital natives. Indeed, they master the use of digital technologies far more the average instructor. Because of cultural and heritage reasons and specific engineering training, there are certain similarities between Spanish and Peruvian university students. The acquisition of digital competences for lecturers is a pending task, with similar features in both countries. This has implied that exam settings have focused in many cases on avoiding cheating. There are currently diverse applications available to share computer desktops or use third-party digital devices, so the authors think that there is broad room for improvements in order to ensure honesty, probity, confidentiality, authorship, and equal opportunities for all exam takers [8,24,26].

This recent global health crisis has shown that the current university learning system is remarkably digital and has just made a step toward the design of the future higher education system. This passes through the use of active learning models and the development of digital competences for educational agents. Other features can be envisaged in this route, including synchronous teaching, ubiquitous learning, and active learning strategies such as synthesis capability, problem-based learning, project-based learning, service-based learning, competence-based learning, and experiential learning [38].

Regarding both the virtual training and ICT-mediated assessment processes, there is much room for improvement, especially when focusing on the formative assessment. These improvements must start at revising their meaning in the future digital context, analyzing their limits and possibilities, determining which types of knowledge are adequate for being evaluated, and identifying the drawbacks and capabilities of virtual tools [45,46]. Indeed, the recent experience revealed that ICT-based evaluation showed a trend toward summative and quantitative assessment, even more when inserted within LMS. Additionally, it has become essential to ensure the effectiveness of the technical and digital layouts of remote evaluation, so these layouts should open for debate. The absence of uniform controls and the pervasive use of digital tools may lead to a loss of quality assurance and, hence, of the evaluation purpose.

Likewise, this recent experience revealed two other challenges: to reduce the digital divide and the lack of inclusion in higher education. This may include facilitating a digital equipment loan service and access to wireless technology to low-income families.

Furthermore, future higher education will be digital, and mobile devices will play a paramount role as they have jumped into the spotlight and become an inseparable tool for university students, who lead technologically-oriented lives. This issue demands a mind shift in educational agents. Likewise, this recent experience also revealed diverse pending tasks about supporting distance-learning students to overcome their lack of motivation and difficulty in understanding some applied courses and remotely oriented work. Only then will they be able to succeed in their study, which could help to decrease the dropout rate. In this regard, digital transformation strategies must also concern research and social service missions.

5.1. Courses at UPM and UJA

Some of the core issues in designing the online evaluation process were as follows. (1) How to promote meaningful learning? (2) Are we actually promoting competition or

improvement? (3) Could we cause a negative impact on low-achieving students? (4) How to keep the same face-to-face exam structure when setting online exams?

The incident depicted in Figure 2 is an example of the ease with which students can form groups online to exchange information during exams. All three students developed an alternate approach that did not belong to the syllabus. On the one hand, this may mean that they did not follow the daily impartations. On the other hand, they incorrectly applied such a method and committed the same mistakes. No other exam taker used such an approach not taught in the course.

After the experience, it appeared to be mandatory that universities take actions to train instructors in the usage of educational technology [39,45]. In this regard, designing an effective and safe online examination strategy is a priority task. Likewise, learning outcomes could be improved by setting up a convenient flow of integrated digital content and online sessions [41,46].

The strategy followed at UJA in this extraordinary situation has proven to be remarkably efficient, since the results obtained by the students did not greatly differ from those of previous courses. Regarding evaluation, no cheating issues were detected. This suggests that, since the group of students was not large, this problem could be kept under control according to this experience. Nevertheless, it was true that this is the first time the students faced this type of exam procedure, and different behavior is expected in the future, once the students are accustomed to it. In the case of UPM, some cases of cheating were detected, as mentioned above, since the number of students was about five times larger than in the case of UJA. From these results, it was concluded that group size is critical in this aspect.

On another note, one of the main lessons learnt during this experience was related to students' motivation. During the online teaching period, the students seemed, in general, to be less engaged with the course, compared with previous years. This could have been due to a higher workload in other courses, which modified their evaluation method and increased their deliverable tasks, reducing the available time for studying and preparing these courses. Moreover, face-to-face teaching implies meeting other peers, having informal talks with lecturers, and (this is probably a key point) increasing the feeling of belonging to a community.

Following this experience, it was concluded that a combination of face-to-face and online learning can lead to a better learning experience, since online resources provide tools and promote dynamics that are not possible in the classroom, but this combination can also lead to a less motivated group of students [26,37].

5.2. Courses at UDEP

The assessment was mainly built on the teamwork method complemented with individual evaluations and a final exam. The LMS played a core role in this process, and students pointed out its reliability.

The numbers of passes showed that the virtual teaching and evaluation system behaved in a similar way to the previous year, which was a face-to-face one. This was due to greater teacher–student interaction and flexibility in dealing with unforeseen technical difficulties. Even so, the small differences could be attributed to the lack of access to technology at home by a few students, i.e., affordability problems. In this sense, this recent experience revealed two other challenges: to reduce the digital divide and the lack of inclusion in higher education. This may include facilitating a digital equipment loan service and access to wireless technology to low-income families [25,26].

5.3. Comparison between Spanish and Peruvian Results

On the one hand, the subjects whose assessment was mainly based on teamwork and CBL yielded similar outcomes. Nevertheless, instructors showed concern about factors that hindered teamwork effectiveness such as compensation for team achievements and boosting personal mind shifts for team members [37].

On the other hand, the rest of the subjects yielded similar outcomes when compared with the face-to-face teaching from the previous year. Both outcome figures (Table 3) and students' perceptions (Tables 4–7) indicated that the measures taken to redress the situation were satisfactory.

Table 4. Results from the survey on student perceptions and degree of fulfillment of expectancies in the courses of strength of materials and construction management taught at UPM.

	Strongly Agree	Agree	Neutral	Disagree	Completely Disagree	Mean	Std. Deviation
(1)	19.4%	19.4%	38.7%	21.0%	1.6%	3.34	1.06
(2)	3.2%	16.1%	45.2%	35.5%	0.0%	2.87	0.79
(3)	3.2%	22.6%	27.4%	27.4%	19.4%	2.63	1.12
(4)	1.6%	21.0%	38.7%	29.0%	9.7%	2.76	0.95
(5)	4.8%	22.6%	33.9%	19.4%	19.4%	2.74	1.15
(6)	3.3%	36.1%	44.3%	14.8%	1.6%	3.25	0.80
(7)	41.9%	40.3%	16.1%	1.6%	0.0%	4.23	0.77
(8)	16.1%	40.3%	41.9%	1.6%	0.0%	3.71	0.75
(9)	13.3%	23.3%	38.3%	18.3%	6.7%	3.18	1.09
(10)	8.2%	41.0%	32.8%	13.1%	4.9%	3.34	0.97
(11)	14.8%	41.0%	19.7%	18.0%	6.6%	3.39	1.13
(12)	3.3%	24.6%	50.8%	21.3%	0.0%	3.10	0.76
(13)	19.7%	37.7%	21.3%	16.4%	4.9%	3.51	1.13

Table 5. Students' perceptions on their goal achievements through the remotely oriented work in course of dynamic and seismic analysis of structures taught at UPM.

	Strongly Agree	Agree	Neutral	Disagree	Completely Disagree	Mean	Std. Deviation
(1)	40.9%	40.9%	15.2%	3.0%	0%	4.20	0.80
(2)	63.6%	27.3%	9.1%	0%	0%	4.55	0.66
(3)	27.3%	54.5%	18.2%	0%	0%	4.09	0.67
(4)	54.5%	9.1%	27.3%	9.1%	0%	4.09	1.08
(5)	45.5%	45.5%	9.1%	0%	0%	4.36	0.64
(6)	9.1%	63.6%	27.3%	0%	0%	3.82	0.57
(7)	2.3%	54.5%	9.1%	0%	9.1%	3.91	1.08
(8)	54.5%	45.5%	0%	0%	0%	4.55	0.50
(9)	54.5%	27.3%	0%	18.2%	0%	4.18	1.11
(10)	0%	36.4%	45.5%	18.2%	0%	3.18	0.72
(11)	9.1%	72.7%	18.2%	0%	0%	3.91	0.51
(12)	9.1%	72.7%	18.2%	0%	0%	3.91	0.51
(13)	45.5%	36.4%	18.2%	0%	0%	4.27	0.75

Table 6. Feedback from the survey on students' perceptions and degree of fulfilment of expectancies in course of research operations I taught at UDEP.

	Strongly Agree	Agree	Neutral	Disagree	Completely Disagree	Mean	Std. Deviation
(1)	13.7%	42.5%	39.7%	1.4%	2.7%	3.63	0.84
(2)	18.5%	54.0%	26.6%	0.8%	0%	3.90	0.69
(3)	57.5%	30.1%	2.7%	0%	9.6%	4.26	1.18
(4)	19.2%	31.5%	38.4%	6.8%	4.1%	3.55	1.01

Table 7. Feedback from the survey on students' perceptions and degree of fulfilment of expectancies in course of research operations II taught at UDEP.

	Strongly Agree	Agree	Neutral	Disagree	Completely Disagree	Mean	Std. Deviation
(1)	17.1%	53.9%	25.0%	3.9%	0%	3.84	0.74
(2)	15.7%	57.9%	24.8%	1.7%	0%	3.88	0.68
(3)	33.8%	42.9%	20.8%	2.6%	0%	4.08	0.80
(4)	62.3%	31.2%	3.9%	2.6%	0%	4.53	0.69

It also seems necessary to reflect on what is an adequate setup and structure for an online exam. University student associations are currently demanding online exams rather than on-site ones. They argue sanitary risk reasons, though they prefer face-to-face lectures. This gives cause for reflection.

Lastly, there is general concern about the two aforementioned challenges, i.e., the lack of inclusion and the digital divide, as priorities for improvement.

6. Final Remarks

The closure of university classrooms caused by the advent of the recent global health emergency has prompted numerous efforts and adaptations to the remote teaching–learning system. Some measures, practices, and changes might be here to stay, including the use of digital tablets in remote teaching, pre-recorded videos with inserted questions to ensure follow-up, preset questionnaires and quizzes for online use, and the capability to meet with students and colleagues.

The adaptability to the constraints imposed by remote teaching has emerged as a key feature: good-achieving students during the face-to-face stage of the semester performed well during the distance-learning phase, whereas low-achieving students became more affected. The dropout rate in fundamental subjects reached 22%, which was notably higher than in technological modules, which was lower than 10%.

Regarding the digital divide and the lack of inclusion as shortcomings, deep reflection is required about setting policies to support and counsel students in order to facilitate their integration and adaptability so that they can better meet their learning outcomes.

Lastly, the impact of this health crisis on higher education has shown the potentials of distance teaching, either synchronous or asynchronous. Conversely, the remote evaluation process still raises technical, functional, and ontological controversies that need to be addressed and improved.

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Article

Academic Self-Perception and Course Satisfaction among University Students Taking Virtual Classes during the COVID-19 Pandemic in the Kingdom of Saudi-Arabia (KSA)

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Abstract: This research study examines academic self-perceptions and course satisfaction among university students and associated factors during virtual classes. A cross-sectional online survey of (n = 328) undergraduate and postgraduate Saudi students who took virtual classes during the second semester of the academic year 2019–2020 and the first semester of the academic year 2020–2021 during the coronavirus disease 2019 (COVID-19) pandemic. The findings demonstrated students' scores on negative academic self-perceptions (mean (M) = 9.84; standard deviation (S.D.) = 3.09) are significantly higher in comparison to positive academic self-perceptions (M = 7.71; S.D. = 2.46) and the difference was statistically significant, t(327) = 3.69, $p < 0.001$. The analysis demonstrated that mean differences were significant across 'year of study', 'field of study', 'CGPA' (cumulative grade points average), 'employment status', 'on-site work' and 'being a parent of young child' ($p < 0.01$). Correlation analysis shows a linear positive association between perceptions of workload and low technical support with negative academic self-perceptions ($p < 0.001$) and an inverse relationship with positive academic self-perceptions ($p < 0.001$). The multiple regression analysis demonstrated that the predictor variables in the model (perceptions of workload and technical support) explain 62% variance in negative academic self-perceptions and 41% variance in positive academic self-perceptions. Furthermore, the analysis demonstrated that positive academic self-perceptions bring a 32% variance in course satisfaction. These findings underscore the importance of balancing workload during online studies in higher education and provision of adequate technical support to reduce the negative academic self-perceptions which are associated with lower levels of course satisfaction. Students' academic self-perceptions and course satisfaction during virtual studies are important factors to retain students' motivation in learning and academic performance.

Keywords: distance education; online learning; academic self-perceptions; workload; technical support; course satisfaction; higher education; COVID-19 pandemic

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1. Introduction

At the beginning of 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) pandemic a public health emergency and urged governments to enforce complete and partial lockdowns to prevent the spread of infection. The COVID-19 pandemic is still an ongoing public health crisis in various regions of the world and has a significant influence on all aspects of life including the academic environment.

In the Kingdom of Saudi Arabia (KSA), to implement precautions against the spread of the virus and to allow for timely control of the disease, physical attendance at schools and universities was suspended on 10 March 2020. Digital distance learning was adopted simultaneously to protect the population from cross-infection [1]. Previous literature has discussed the wider context of distance/online studies such as economic drifts, political atmosphere and advancements in information and communication technology as some of the significant factors associated with the growth and implementation of digital distance education before the COVID-19 pandemic [2]. However, the implementation of online education/distance education became the only choice for educational institutions to continue their academic activities during the COVID-19 pandemic.

"Distance education" refers to an approach to education in which learners and lecturers are somewhat isolated in time and space with no in-person contact whereas online learning refers to the use of information and communication technology to deliver lectures and share instructional materials [3]. The rapid advancements in internet-based information technology and the development of more sophisticated learning management systems in the developed countries played a pivotal role in the immediate execution of digital distance education during the COVID-19 pandemic [4,5]. However, this sudden implementation of distance education was associated with hiccups and required lots of quick adaptations in academic regulations, less familiar modes, and methods of assessment in addition to frequent shifts in the study and exam schedules. All these issues contributed to the academic workload and were sources of stress for students. Preliminary studies regarding online learning during the COVID-19 pandemic show that students developed mixed feelings about virtual classes and reported low to moderate levels of satisfaction with remote/online studies [6,7]. The studies conducted prior to the COVID-19 pandemic also demonstrated students usually are discontented and not happy with their online study experiences and virtual education was a less preferred option for education [8,9].

Online learning environments require the practice of academic self-regulation and problem-solving skills and students should be proficient in utilizing online learning resources to fulfill the demands of undergraduate and post-graduate degree programs [10]. Previous literature identifies how both academic and non-academic factors play a significant role in the self-regulation and academic self-perceptions of students [11,12]. A study from Romania [13] showed that students reported more disadvantages of online studies and considered it less beneficial in terms of achieving learning outcomes. When shifted to exclusive online studies during the COVID-19 pandemic, students reported a lack of focus and attention due to several factors such as lack of physical space in homes, and presence of family members while they are taking online classes. Furthermore, students reported being afraid of possible criticisms or humiliation during the online presentations of their assignments and projects. Furthermore, the lack of technical skills of both teachers and students was a relevant factor in determining their satisfaction with virtual studies [11,12].

Students' satisfaction with online studies is linked with student perceptions about online studies as well as students' actual experiences of online studies [14]. Additionally, online course satisfaction was associated with factors such as computer competency, technology orientation and smooth delivery of course contents through online platforms [15]. Previous research in the context of institutional education demonstrates that students' academic self-perceptions play a critical role in student's academic performance [16]. Whereas academic self-efficacy and computer self-efficacy of students in online education programs have positive influences on student academic motivation and satisfaction [15]. The recent studies from some regions of the world assessed students' online study experiences, stress levels and course satisfaction [6,7,13]. However, to date there is no study from Saudi Arabia which assessed factors that associate with positive and negative academic self-perceptions and course satisfaction keeping in view the scenario of the complete and immediate shift to distance education during COVID-19 pandemic.

Consistent with prior arguments, the current study aims to assess the relationship of students' perceptions of workload and availability of technical support with academic

self-perceptions and course satisfaction during distance education. Some of the research questions set for this analysis were:

(i) Is there a significant difference between positive and negative academic self-perceptions of students taking virtual classes during the COVID-19 pandemic?
(ii) What is the nature of the relationship between students' perceptions of workload and availability of technical support with positive and negative academic self-perceptions?
(iii) Do positive and negative self-perceptions during online studies impact student's course satisfaction?

Theoretical Framework

The literature demonstrates that students who hold positive perceptions regarding their academic competence are more likely to retain focus and interests in their academic tasks such as assignments, projects, presentations and perform better on achievement tests [14]. Students' academic self-perceptions relate to their intrinsic academic motivation and academic self-confidence, which ultimately enhance students' engagement and focus on studies needed to excel in competitive academic environments of modern times [17]. The self-enhancement model proposed by Flook et al. (2020) also suggests that positive academic self-perceptions have a significant role in student's academic achievement [18]. The psychological processes involved in the development of academic self-perceptions may include self-esteem and self-confidence [19]. Nonetheless, learning context and environmental factors also have a role in determining student's academic self-perceptions [20].

Previous studies reported student-related factors such as high levels of academic motivation and self-regulation as key skills to excel in online courses [21]. This is partly due to the increasingly autonomous nature of online learning environments as opposed to conventional classroom contexts. The skill development model proposes that educational achievements primarily influence academic self-concepts in several ways [22]. For instance, the experiences of academic achievements and failures let students go through cycles of shaping and reshaping their academic self-perceptions. Additionally, the appraisal of teachers and parents also has significant influences on the development of academic self-perceptions [23]. Although students in higher education are relatively immune to such influences, however, the sudden and complete shift to digital distance education during the COVID-19 pandemic generated feelings of confusion and fear in students [24,25] because, for many students, it was a new way of studying in an unfamiliar academic climate. Additionally, teachers are also still experimenting with different teaching strategies to achieve learning outcomes for courses across various disciplines/fields of study in higher education [13,26]. Consequently, several factors are playing a role in determining student experiences and satisfaction with online studies during the COVID-19 pandemic. A recent study assessed the mental well-being of university students during the COVID-19 pandemic in Italy [27] and demonstrated that positive beliefs about academic self-efficacy and satisfaction with study-related experiences have a protective role in students' psychological and emotional health. Research demonstrates that students' self-confidence associate with the usefulness of virtual classes [15].

It is hypothesized that other than background factors such as gender, age, year of study, the field of study, cumulative grade points average (CGPA), the factors such as perceptions of workload during virtual classes and practical factors such as availability of technical support may be associated with student's academic self-perceptions which ultimately influence students' satisfaction with virtual classes held during the COVID-19 pandemic. Figure 1 presents the schematic diagram to demonstrate the proposed nature of the relationship between study variables.

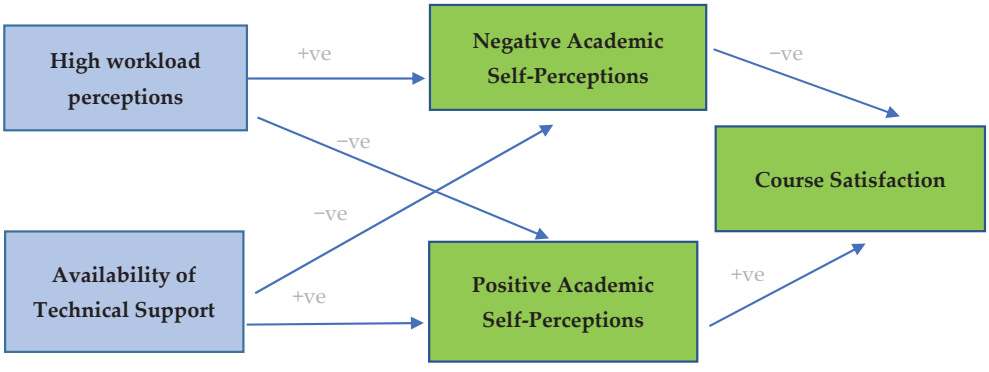

Figure 1. Schematic diagram for study model.

2. Materials and Methods

2.1. Data Collection Procedure

The data for this study was collected via an anonymous online survey. The study invitation and study questionnaire including informed consent were shared with prospective participants through the researcher's professional contacts and students' groups in higher education institutions in the Kingdom of Saudi Arabia (KSA). The data collection was completed between the first week of October 2020 till the end of November 2020. In KSA, to prevent the spread of COVID-19 infection, all educational institutions completely shifted to digital distance education from March 2020 (to date, February 2021).

2.2. Sample Size

The minimum sample size estimated to be (n = 305) when calculated by $\frac{\mathbf{z}^2\mathbf{P}(1-\mathbf{P})}{\mathbf{d}^2}$, with the assumption that the proportion of perceived academic stress lies between 14.4% to 33.2%, with a 95% confidence interval (CI) and 0.05 precision [7]. The sample was recruited by employing a convenience sampling method. The online link of the study questionnaire was shared with the target population through professional colleagues working in universities located in four regions (Ha'il, Madina, Dammam and Riyadh) of KSA. A total of (n = 359) students accessed the study link out of which (n = 328) voluntarily completed the study questionnaire thus achieving the response rate of 90% approximately.

2.3. Study Questionnaire

2.3.1. Background Characteristics

The first section of the survey questionnaire collected data about demographic and academic variables. These included gender, age, field of study, academic degree, year of study, CGPA, work status, working condition (online vs. onsite) and being a parent of the young child (0–5) years.

2.3.2. Academic Self-Perceptions

Academic self-perceptions refer to academic self-confidence. This was measured by employing a sub-scale on the Perception of Academic Stress Scale (PAS) [28]. It is comprised of six items and measures both positive and negative dimensions of academic self-perceptions. The negative dimension focuses on the fear of failing in courses, perceiving teachers as more demanding pertaining to academic performance, and seeing oneself being unable to catch up with academic tasks. The positive dimension focuses on confidence for success as a student, confidence in making the right academic decisions, and confidence in the future career. The items on these scales were assessed for relevance and appropriateness by 12 experts from the Faculties of Psychology and Educational Psychology who gave

feedback about each item. To generate evidence, about-face validity and content validity experts rated each item for its appropriateness and relevance, on a five-point Likert scale (1 = extremely irrelevant, 2 = irrelevant, 3 = slightly relevant, 4 = relevant, and 5 = strongly relevant). These items were selected as the mean score of expert's ratings on these items were 3.5 or above [28]. The items were also reviewed for clarity and grammatical corrections and simplicity to ensure that students could easily understand and interpret. Each item is rated on a 5-point Likert scale rating (highly disagree = 1 to highly agree = 5). A higher score on each dimension means higher negative or positive academic self-perceptions. The authors of this scale assessed internal reliability and convergent validity through administration in a sample of 100 university students [28]. The analysis demonstrated acceptable internal consistency reliability, and there is evidence for convergent validity supported by a significant positive association with the academic expectations' subscale and workload subscale ($p < 0.01$). The Cronbach Alpha reliability estimates in our sample on the dimension of negative academic self-perceptions was ($\alpha = 0.78$) and on the dimension of positive academic self-perceptions was ($\alpha = 0.91$).

2.3.3. Course Satisfaction

Course satisfaction in the context of higher education has been described as '*short-term attitude resulting from an evaluation of students' educational experience, services, and facilities*' [29]. It was assessed by using a set of five items used in previous research [30] to measure course satisfaction among students studying in an online learning environment. The sample items include "*I felt, I achieved the course objectives in this online course*"; "*If I had a choice, I would take an online course rather than a traditional face-t-face class*". Items are rated on 5-point Likert scale rating (highly disagree = 1 to highly agree = 5). Higher score means higher levels of course satisfaction. The internal consistency as assessed in a previous study [30] on a sample of 110 students in higher education was ($\alpha = 0.93$) whereas in the current study it is ($\alpha = 0.90$).

2.3.4. Perceptions of Workload during Distance Education

The perceptions of workload during distance education refer to stresses relating to excessive workload due to distance education, lengthy online assignments, and online examinations [30,31]. It was measured by three items on the sub-scale Perceptions of Workload; the authors of the original study demonstrated that the scale possesses adequate psychometric properties in addition to a qualitative assessment of items by field experts in terms of relevance and appropriateness [28]. Each item is rated on a 5-point Likert scale (highly disagree = 1 to highly agree = 5). A higher score means perceiving the workload during distance education as high. The Cronbach Alpha reliability estimate in the previous study [28] was ($\alpha = 0.69$) and in the current study is ($\alpha = 0.78$).

2.3.5. Availability of Technical Support

The availability of technical support during distance education refers to students' judgment about access to adequate help in resolving technical issues during online education. It was measured by a scale comprising of a set of four questions. The items on the scale were assessed for their relevance and appropriateness by field experts and the scale has been used in a previous study to assess students' perceptions of technical support during distance education [30]. The internal reliability of the scale estimated after administration on a sample of 110 students in higher education was ($\alpha = 0.76$) [30]. The items are rated on a 5-point Likert scale (highly disagree = 1 to highly agree = 5). The Cronbach Alpha reliability in our study it is ($\alpha = 0.77$).

2.4. Data Analysis Procedure

The data were analyzed by using IBM Statistical Package for Social Sciences (SPSS) software (25.0 version) IBM Corp, New York (NY), United States of America (USA). The descriptive characteristics of variables under study were described using mean scores and

percentages. Prior to the application of parametric tests, the data were assessed for the fulfillment of assumptions (linearity; normality of the distribution; independence of the observations; and non-multicollinearity of the independent variables) which were found to be in an acceptable range. The significance of mean differences between negative and positive academic self-perceptions was determined by a paired sample *t*-test. The mean differences in academic self-perceptions across background variables were assessed by using an independent sample *t*-test and analysis of variance (ANOVA). Pearson correlation assessed the bivariate association between perceptions of workload and technical support with academic self-perceptions and course satisfaction. Multiple regression analysis was applied to determine the predictive role of perceptions of workload and availability of technical support during distance education with academic self-perceptions and course satisfaction. The *p*-value significance was chosen at $p < 0.05$ for all inferential statistics.

2.5. Ethical Approval Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Research Ethics Committee (REC) at the University of Ha'il (protocol code H-2020-091) dated 10/05/2020.

3. Results

The sample included (n = 328) university students. In terms of sociodemographic characteristics, the participants were mostly female (n = 233; 71%), majority aged between 21–25 years (n = 236; 72%). Nearly half of the participants were working students (n = 172; 52%) among whom (n = 147; 45%) worked from a worksite. Nearly one quarter (n = 77; 23%) were parents of a young child (0–5 years old). Most were in a Bachelor program (n = 151; 87.3%), and the majority in the fourth year (n = 139; 42%) followed by the third year (n = 111; 34%). The majority were students of Medical/Health Sciences (n = 43; 24.9%); followed by Business and Management Sciences (n = 60; 18%), Basic Sciences (n = 46; 14%) and Engineering (n = 38; 12%). In terms of academic performance, (n = 163; 50%) had CGPA above than 3.0 followed by (n = 96; 29%) with CGPA between 2.5–3.0, and 1% reported CGPA less than 1.5.

3.1. Academic Self-Perceptions, Technical Support, Perceptions of Workload and Course Satisfaction among University Students Taking Online Classes during Coronavirus Disease 2019 (COVID-19) Pandemic

Table 1 illustrates the mean scores obtained by students on measures of academic self-perceptions, technical support, perceptions of workload and course satisfaction. The ratings were obtained by participants on a set of statements on a five-point Likert scale where 1 represents "I strongly disagree" and 5 represents "I strongly agree". The means' analysis demonstrates that students' scores are above the scale's midpoint on items tapping negative academic self-perceptions (mean (M) = 9.84; standard deviation (S.D.) = 3.09).

Table 1. Mean scores on items and scales measuring academic self-perceptions, technical support, perceptions of workload and course satisfaction (n = 328).

Dimensions and Sub-Dimensions of Measures	M (S.D.)
Negative Academic Self-Perceptions (t(327) = 3.69, $p < 0.001$)	9.84 (3.09)
Positive Academic Self-perceptions	7.71 (2.46)
Low Technical Support	6.68 (2.04)
High Technical Support	5.29 (2.11)
Perceptions of workload	11.1 (2.78)
Course satisfaction	12.1 (3.21)

M = Mean; S.D. = Standard Deviation.

These findings verify that university students were afraid of failing the course during virtual studies (M = 3.31; S.D. = 1.26), struggling to catch up with academic tasks (M = 3.33; S.D. = 1.17) and perceive their teachers are hard about academic performance (M = 3.21;

S.D. = 1.17). Furthermore, the results from paired samples *t*-test demonstrate that students' scores on negative academic self-perceptions (M = 9.84; S.D. = 3.09) are significantly higher in comparison to positive academic self-perceptions (M = 7.71; S.D. = 2.46) and the difference was statistically significant, t(327) = 3.69, $p < 0.001$. Students also reported low levels of technical support (M = 6.68; S.D. = 2.04) with statistical significance t(327) = 7.48, $p < 0.001$. Furthermore, analysis of the means demonstrates that students' scores are above the scale's midpoint on perceptions of workload (M = 11.1; S.D. = 2.7) and below the scale's midpoint on course satisfaction (M = 12.1; 3.2).

3.2. Mean Differences in Academic Self-Perceptions of University Students across Demographic and Educational Background Variables

Table 2 illustrates the mean differences in academic self-perceptions across background variables. The analysis demonstrated that mean differences were significant across 'year of study', 'field of study', 'CGPA', 'employment', 'on-site work' and 'being a parent of young child' ($p < 0.001$).

Table 2. Mean differences on academic self-perceptions across background variables ($n = 328$).

Variable	Categories	f (%)	Negative Academic Self-Perceptions M (S.D.)	Positive Academic Self-Perceptions M (S.D.)
Gender 1. t(326) = 1.44, $p = 0.54$ 2. t(326) = 0.05, $p = 0.21$	Male	95 (29%)	9.46 (3.05)	7.73 (3.36)
	Female	233 (71%)	10.0 (3.01)	7.71 (3.46)
Age Categories F(2) = 0.26, $p = 0.77$ F(2) = 0.44, $p = 0.64$	<20 years	72 (22%)	9.62 (3.11)	7.74 (3.56)
	21–25 years	236 (72%)	9.89 (3.04)	7.64 (3.43)
	26–30 years	20 (6.1%)	10.0 (2.62)	7.40 (3.56)
Academic Degree t(326) = 0.39, $p = 0.69$ t(326) = 1.04, $p = 0.29$	Bachelor	292 (89%)	9.82 (3.06)	7.64 (3.42)
	Masters	36 (11%)	10.03 (2.78)	7.28 (3.74)
Year of Study F(3) = 4.26, $p < 0.01$ F(3) = 10.02, $p < 0.001$	First Year	33 (10%)	9.09 (3.11)	9.36 (3.37)
	Second Year	45 (14%)	10.47(3.05)	7.02 (2.86)
	Third Year	111 (34%)	10.45 (2.91)	7.05 (3.35)
	Fourth Year	139 (42%)	9.33 (2.99)	9.40 (3.42)
Field of Study F(3) = 6.85, $p < 0.001$ F(3) = 4.91, $p < 0.01$	Medical/Health Sciences	184 (56%)	9.23 (3.01)	9.29 (3.48)
	Engineering	38 (12%)	10.18 (2.31)	7.71 (2.91)
	Business & Management Sciences	60 (18%)	10.45 (3.08)	7.83 (3.51)
	Basic Sciences (Biochemistry, Biology, Zoology, Physics)	46 (14%)	11.2 (2.97)	7.54 (3.29)
CGPA F(3) = 4.77, $p < 0.01$ F(3) = 5.01, $p < 0.01$	<1.5	4 (1%)	12.75 (1.51)	4.75 (2.06)
	1.5–2.4	65 (20%)	9.77 (3.05)	7.02 (2.91)
	2.5–3.0	96 (29%)	10.59 (2.82)	7.29 (3.31)
	>3.0	163 (50%)	9.36 (3.05)	7.33 (3.64)
Employed t(326) = 0.99, $p = 0.32$ t(326) = 3.21, $p < 0.05$	Yes	172 (52%)	10.2 (3.08)	7.03 (3.42)
	No	156 (48%)	9.51 (2.94)	7.24 (3.41)
Working from worksite t(326) = 2.91, $p < 0.01$ t(326) = 3.94, $p < 0.001$	Yes	147 (45%)	10.3 (2.96)	7.29 (3.26)
	No	181 (55%)	9.41 (3.02)	8.38 (3.48)
Being a Parent of young child (0–5 years) t(326) = 3.21, $p < 0.01$ t(326) = 4.09, $p < 0.001$	Yes	75 (23%)	10.81 (3.07)	7.31 (3.32)
	No	253 (77%)	9.55 (2.95)	8.13 (3.39)

Note: 1 = Negative Academic Self-perceptions; 2 = Positive Academic Self-perceptions; M = Mean; S.D. = Standard Deviation.

3.3. Relationship of Perceptions of Workload and Technical Support with Academic Self-Perceptions

The Pearson correlation analysis presented in (Table 3), shows a statistically significant and positive correlation between the availability of technical support and negative academic self-perceptions and an inverse relationship with positive academic self-perceptions ($p < 0.001$). Furthermore, there was a statistically significant positive correlation between

perceptions of workload during online studies and negative academic self-perceptions and there was a statistically significant negative association between perceptions of workload and positive academic self-perceptions ($p < 0.001$). Positive academic self-perceptions have a statistically significant positive correlation with course satisfaction ($p < 0.001$) and negative academic self-perceptions have a negative relationship with course satisfaction ($p < 0.001$).

Table 3. Relationship of perceptions of workload and technical support with negative and positive academic self-perceptions of university students during online studies ($n = 328$).

	Low Technical Support	High Technical Support	Perceptions of Workload	Negative Academic Self-Perceptions	Positive Academic Self-Perceptions	Course Satisfaction
Low Technical Support	-	−0.34 ***	0.26 ***	0.29 ***	−0.36 ***	−0.38 ***
High Technical Support		-	−0.38 ***	−0.36 ***	0.61 ***	0.49 ***
Perceptions of workload			-	0.78 ***	−0.31 ***	−0.41 ***
Negative Academic Self-Perceptions				-	0.45 ***	−0.42 ***
Positive Academic Self-perceptions					-	0.55 ***
Course Satisfaction						-

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

3.4. Predictive Role of Perceptions of Workload and Technical Support in Academic Self-Perceptions

Table 4 presents findings from multiple regression analysis to demonstrate the predictive role of independent variables. Findings demonstrate that low technical support and perceptions of workload were significant predictors of negative academic self-perceptions. The multiple regression equation with the ANOVA test was found to be significant at ($F(3, 324) = 178.835$, $p < 0.001$) with an R2 of 0.62. The predictor variables in the model explain a 62% variance in negative academic self-perceptions. The negative academic self-perceptions increased 7% for each unit in lack of availability of technical support. The negative academic self-perceptions increased up to 74% for each unit increase in perceptions of workload. Thus, perceptions of workload appeared to be the most significant predictors of negative academic self-perception among university students taking virtual classes during the COVID-19 pandemic.

Table 4. Multiple regression analysis to demonstrate the independent role of perceptions of workload and technical support in academic self-perceptions of students taking online classes ($n = 328$).

Negative Academic Self-Perceptions as Criterion Variable					
Predictor Variables	B	SE	β	*t*	95% CI
Low Technical Support	0.117	0.055	0.079	2.15 *	0.010–0.225
High Technical Support	−0.074	0.055	−0.052	−1.348 ns	−0.183–0.034
Perceptions of workload	0.809	0.041	0.743	19.92 ***	0.729–0.888
R			0.79		
R2			0.62		
F-change			178.83 ***		
Positive Academic Self-Perceptions as criterion variable					
Predictor Variables	B	SE	β	*t*	95% CI
Low Technical Support	−0.298	0.078	−0.176	−3.82 ***	−0.451−−0.145
High Technical Support	0.863	0.079	0.526	10.96 ***	0.708–1.01
Perceptions of workload	−0.091	0.058	−0.073	−1.57 ns	−0.207–0.023
R			0.64		
R2			0.41		
F-change			75.92 ***		

Note: *** $p < 0.001$; ** $p < 0.01$, * $p < 0.05$; ns = non-significant. B = Unstandardized Coefficients; SE = Standard Error; β = Standardized Coefficients; *t* = *t*-test; 95% CI = 95% Confidence Interval.

Regarding positive academic self-perceptions, both low and high technical support appeared to be significant predictors in the model whereas perceptions of workload did not appear as a significant predictor for positive academic self-perceptions. The multiple regression equation with ANOVA test was found to be significant ($F(3, 324) = 75.92$, $p < 0.001$) with an R2 of 0.41. The predictor variables in the model explain a 41% variance in positive academic self-perceptions. Access to adequate technical support appeared to be the most significant predictor of positive academic self-perception among university students taking virtual classes during the COVID-19 pandemic.

3.5. Predictors of Course Satisfaction during Virtual Classes

Table 5 presents findings from multiple regression analysis to demonstrate the predictive role of technical support, perceptions of workload and academic self-perceptions in course satisfaction during virtual studies.

Table 5. Multiple regression analysis to demonstrate role of technical support, perceptions of workload and academic self-perceptions in course satisfaction ($n = 328$).

Course Satisfaction as Criterion Variable					
Predictor Variables	B	SE	β	*t*	95% CI
Constant	13.25	1.68		7.86 ***	9.93–16.57
Low Technical Support	−0.382	0.121	−0.150	−3.16 **	−0.619–−0.144
High Technical Support	0.408	0.140	0.165	2.91 **	0.132–0.684
Perceptions of workload	−0.318	0.133	−0.170	−2.38 *	−0.580–−0.055
Negative Academic Self-perceptions	−0.072	0.127	−0.042	−0.565 ns	−0.322–0.179
Positive Academic Self-perceptions	0.491	0.089	0.327	5.51 ***	0.316–0.667
R			0.64		
R2			0.41		
F-change			44.63 ***		

Note: *** $p < 0.001$; ** $p < 0.01$, * $p < 0.05$; ns = non-significant. B = Unstandardized Coefficients; SE = Standard Error; β = Standardized Coefficients; *t* = t-test; 95% CI = 95% Confidence Interval.

Findings demonstrate that positive academic self-perceptions and access to technical support significantly contribute to course satisfaction. The multiple regression equation with ANOVA test was found to be significant ($F(3, 322) = 44.618$, $p < 0.001$) with an R2 of 0.41. The predictor variables in the model together explain 64% variance in course satisfaction. Positive academic self-perceptions, perceptions of workload and access to technical support appeared to be the most significant predictors of course satisfaction among university students taking virtual classes during the COVID-19 pandemic.

4. Discussion

The current study sought to examine academic self-perceptions of university students in KSA who shifted to virtual classes during the last two academic semesters to control the exponential growth of COVID-19 infections in the communities. Furthermore, it assessed the predictive role of perceptions of workload in virtual classes and the availability of technical support in determining academic self-perceptions and their relationship with course satisfaction. Findings demonstrate that overall students have higher negative academic self-perceptions in comparison to positive academic self-perceptions. This shows that students are more likely to have a fear of failing courses this year, difficulty in catching up with academic tasks, and perceiving teachers being harder on them with regard to their academic performance. The difference in academic self-perceptions was non-significant across gender, age and academic degree whereas those students who had CGPA <1.5 and those who had CGPA between 2.5–3.0 had more negative academic self-perceptions in comparison to those who had CGPA >3.0. Additionally, students who were employed and working from worksites and those who were parents of young children (0–5 years old) had more negative academic self-perceptions. Findings demonstrate that low technical support significantly contributes to negative academic self-perceptions and high technical

support significantly contributes to positive academic self-perceptions. Findings revealed an inverse relationship of low technical support and perceptions of the workload with course satisfaction during online studies. The positive academic self-perceptions appeared as the most significant predictor of course satisfaction.

Students' having mixed feelings about online studies during the COVID-19 pandemic and perceptions of increased workload is demonstrated by other researchers' findings [4,21]. A Portuguese study also showed that students have serious concerns regarding the impact of the COVID-19 pandemic on their academic journey and reported excessive academic activities, more assignments and lack of concentration [6]. However, there are interspersed indications about the impacts of the COVID-19 pandemic on the mental health and well-being of students. For instance, a study from Sweden documented a substantially higher prevalence of depressive symptoms in students during the COVID-19 pandemic when matched with the pre-pandemic national population [32]; whereas a study from Italy reported that psychological health and levels of academic stress among university students were not significantly higher than those before the COVID-19 outbreak [27]. A study from China reported that students in higher education were more likely to experience Post-traumatic Stress Disorder (PTSD) symptoms and supported the negative influence of challenges during online studies such as (restricted or no social contact with research supervisors/instructors and less privacy of personal information) on students' mental health [33]. This presentation of findings from literature validates our study findings which demonstrate increased perceptions of workload and low technical support during online education and its negative impact on students' course satisfaction. Whereas our study showed that positive academic self-perceptions predicted higher course satisfaction which aligns with findings from a recent study that indicated a positive association of students' self-efficacy and course satisfaction with emotional well-being [27]. Empirical research from before the COVID-19 pandemic has demonstrated that several factors may influence students experiences of digital distance learning, for instance, computer self-efficacy associate with academic self-efficacy of students in virtual studies [16]. A recent qualitative study from the USA [34] reported that some of the challenges in remote education were miscommunication, a less conducive online learning environment, and increased workload. In our study, we also found that low levels of technical support positively associate with students' negative academic self-perceptions and inversely associate with online course satisfaction. Previous literature reported [35] students' self-efficacy regarding a learning management system (LMS), self-regulation, and time management skills are important factors in perceived satisfaction and usefulness of online courses.

Our study findings demonstrated that students with low CGPA had higher negative academic self-perceptions which align with previous literature about the reciprocal relationship of academic achievement with academic self-perceptions [15]. It is likely that students with a prior low academic performance developed an intensified fear of failing and a struggle in catching up with studies due to emergency shifts and extended duration of online studies. In KSA, students complete their initial school education in their native language and are generally less well-versed in English when they join the university. During online education in higher education, many instructors focus on reading and writing assignments to meet the learning objectives in English because it is the primary medium of instruction at the university level. Limited English language competency may also be a barrier for Saudi students causing heightened perceptions of workload and negative academic self-perceptions.

Current study findings show that students who are working from their worksite and students who are parents are more likely to have negative academic self-perceptions during this challenging time. Students who are employed and parents have additional responsibilities. In the current study, we had a larger proportion of female participants which explains this relationship. In Saudi culture, women get married relatively at younger age and thus many female students in undergraduate and post-graduate programs are usually mothers of young children. During the COVID-19 pandemic, not much social

support was available to young mothers and their children due to the lockdown and implementation of social distancing measures. The cumulative impact of these instances are likely to cause higher perceptions of academic workload during virtual classes, negative academic self-perceptions and low levels of online course satisfaction. Other researchers have also highlighted the importance of care and compassion to be shown to students in higher education during online studies which were being held in the midst of the COVID-19 pandemic [34]. Mothers of young children seeking higher education not only need to catch up with their academic workload but also take care of the requirements of their children's online studies during the pandemic. This implies provision of support through more flexibility in assignment deadlines and the more emphatic response of teachers while handling their queries and concerns. A recent study [36] assessed the protective role of social connectedness against academic stress and found that a sense of belonging with the academic community has positive influences on student's self-efficacy which equips them to cope with the challenges of distance education.

The current study reveals the role of appropriate technical support during online classes in positive academic self-perceptions and course satisfaction, and thus the findings imply that higher education institutions must invest more in the provision of timely and adequate technical support during virtual classes. Other studies conducted in the early phase of the pandemic in KSA [7,25] reported that university students in rural regions had serious concerns about weak internet connectivity, server breakdown, difficulties in log in to the network and taking courses, not meeting the timely submission of homework assignments due to failures in connecting with the LMS. Students reported that frequent interruption in the internet connection was very upsetting during the lectures and they were less satisfied with the built-in support features of the LMS system to address the technical issues during online sessions [7,25]. The Government of Saudi Arabia responded to these issues through the development of a digital distance education framework under which several initiatives were taken by the Ministry of Education and educational institutions to facilitate remote studies during the COVID-19 pandemic [37]. To date, all the educational institutions in KSA are abiding by the government instruction of virtual studies, however, there is a need to optimize the digital services and develop effective technical support mechanisms for students to enhance their course satisfaction. Moreover, virtual education is not only about improving internet connections, but the focus should be on the development of effective online pedagogical approaches keeping in mind the social and cultural factors across various communities that influence students' academic motivation, perceptions of workload, self-regulation, and academic self-perceptions [38]. Keeping this in mind, the perspective of the collectivist culture of Middle Eastern society, where the focus is more on the collective self rather than the individual self, the negative academic self-perceptions could be due to high expectations of significant others such as parents and other family members.

Overall study findings signify a need to enhance academic self-perceptions of students in higher education taking virtual classes during the COVID-19 pandemic because academic self-confidence equips them to feel more capable and confident in their abilities to be successful as academics and pursue future career goals [39,40]. The non-significant association of perceptions of the workload with positive academic self-perceptions warrants further investigation because it raises more questions regarding factors that need to be addressed to enhance student academic self-confidence during virtual studies. Some of the study limitations relate to cross-sectional research design, convenience sample and online data collection on the Likert rating scale. The data were collected during the running semesters and students are already bearing with a lot of online activities; thus saturation or lack of attention might have caused some bias in student's responses. We tapped on a limited number of factors that may associate with students' academic self-perceptions and course satisfaction. Keeping in mind the wide range of course designs in higher education and varying experiences with distance studies during the COVID-19 pandemic, there is a need to identify the role of various other academic and non-academic factors. Future

research should explore multiple dimensions of online studies during and post-crisis times which might have influenced student's academic self-perceptions and course satisfaction. In particular, there is a need to expand our understanding about the underlying reasons for students' perceptions of 'failing courses this year' and 'teachers are hard about my academic performance'. Future research should focus on examining students' perceptions of specific factors that students were more pleased with during virtual classes to improve distance learning approaches and pedagogical techniques. Additionally, there is a need to examine how personal factors (such as poor self-regulation skills and low computer self-efficacy), social factors (such as low social support), and environmental factors (poor IT infrastructure) may be associated with students' perceptions of workload during digital distance learning across various regions and communities.

5. Conclusions and Implications

The results of this study provided insights into the nature of concerns held by university students attending virtual classes during the COVID-19 pandemic in KSA. The negative academic self-perceptions held by students need attention and influenced their satisfaction with online studies. This study also has practical implications. For example, the results demonstrate the significance of adequate and timely technical support during digital education that can enhance students' academic self-perceptions and online course satisfaction. The results suggest that governments should devise policies and programs to improve digital services and educational institutions should focus more on academic and technical support to students. The instructors in higher education institutions should be oriented to student's concerns and emphasis be made on creating more conducive online learning environments without compromising much on the learning objectives set for professional courses and degree programs. In higher educational institutions, the educators are also academic advisors and usually provide counseling to students. Given the context of the COVID-19 pandemic, additional counseling and support services should be initiated by educational institutions to neutralize fears among students related to distance education as well as helping them to improve their self-regulation skills and time management. In KSA, mostly, students are relatively less proficient in English due to minimal exposure to the English language in early education. However, English is the primary medium of instruction for most undergraduate and post-graduate degree programs. During virtual classes in higher education, many instructors focus on reading and writing assignments to meet the learning objectives. Limited proficiency in the English language could be a potential barrier in understanding the course materials and online learning resources, and thus may contribute to the heightened perceptions of academic workload and negative academic self-perceptions. Lastly, the pattern of findings urges further investigation to rule out other factors and the phenomenon behind the perceptions of increased academic workload during virtual studies. Current study findings point to the importance of attending to both psychological factors (such as perceptions of workload) and online course factors (such as technical support) to enhance students' academic self-confidence and course satisfaction during the COVID-19 pandemic.

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Lecturer Readiness for Online Classes during the Pandemic: A Survey Research

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Abstract: Due to the COVID-19 pandemic, most educational institutions across the world have shifted their teaching and learning processes and put efforts into preparing online distance education to ensure education continues uninterrupted. Some did not face difficult tasks or challenges during this process because they were already implementing online or blended learning before the pandemic. However, some institutions, lecturers and students were not ready to adapt to the conditions, and it is therefore important to examine to what extent lecturers are ready to teach online. This research aims to evaluate the readiness of lecturers during a pandemic that arises unexpectedly. It also aims to investigate the weaknesses and obstacles that lecturers must overcome in order to teach an online class. This research applies a mixed-method approach. Lecturers were surveyed through online preparedness questionnaires, and several themes were constructed from the gathered qualitative data. The results show that lecturers have strong baseline technical skills to use e-learning platforms for online courses; they have quickly adapted to using a Learning Management System (LMS), and most have a tactical solution for most online classes with insufficient feasibility, but they do not have a strategic solution. Their sufficiency for teaching online courses was not optimised since they did not fully believe the learning goals could be achieved. This paper elaborates on the theoretical and practical implications.

Keywords: instructor readiness; e-learning readiness; online teaching; pandemic

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1. Introduction

The digital era encourages the use of Information Technology (IT) in the education sector. It facilitates online classes as a manifestation of the e-learning concept and allows lecturers and students to engage in a virtual environment, although physically separated. A concrete example of IT utilisation is a Learning Management System (LMS) platform that mediates learning processes by enabling course material repositories, student activity trackers, assignment submission and review and discussion amongst participants. Online classes are a growing trend in digital transformation and are offered by many universities, but online classes are partially combined with physical classes. Moreover, many universities use an LMS only as a course-material repository and course reporting system because there is less communication and interaction amongst participants than in a physical class.

Unexpectedly, the COVID-19 virus spread, and the World Health Organization declared COVID-19 a global pandemic, which spread to more than 150 countries. It led to the closure of offices, markets, schools and all public areas [1] in an effort to minimise the spread of the virus. Universities in Indonesia ceased all physical activities, and people rushed to carry out their activities online [2]. To continue the learning process, the Republic of Indonesia's Ministry of Education instructed all institutions to switch to fully online classes as an alternative. Unfortunately, this policy was implemented without assessing

lecturers' readiness, and the government should have been more agile. There was a similar situation in other countries [3–5].

Online class implementation required a radical change by lecturers and students regarding communication style, summative assessments and content delivery. As a fundamental problem, only a few lecturers had enough experience to conduct online courses [6], especially fully online courses. However, e-learning was expected to positively impact motivation, autonomy and student participation [7]. Therefore, readiness should be considered a critical factor when determining the success of implementation [3]. In addition, the understanding of lecturers' readiness needs to be ensured [5,8] in order to guarantee that online learning is implemented successfully. Previously, Scherer et al. [9] reported the quantitative measurement of online teaching in higher education since the occurrence of the COVID-19 pandemic. Unfortunately, it did not involve Indonesia, which has various population characteristics and unequal digital literacy. In another case, Pokrovskaia et al. also identified the e-learning implementation in Russia during the COVID-19 pandemic using three hypotheses [10] which its results focused on hypotheses testing only. Those studies utilized a quantitative approach only so the respondents were limited in expressing their perception when evaluating the online classes.

This research aims to evaluate the readiness of lecturers during a pandemic that has arisen unexpectedly. This research also has the purpose to investigate the weaknesses and obstacles that lecturers must overcome in order to teach an online class when required to do so. This study is guided by the following research questions:

1. What are lecturers' readiness levels to conduct online classes during a pandemic?
2. What are lecturers' expectations when participating in online distance education?

This research considers whether all lecturers have appropriate readiness to conduct online classes. As a practical benefit, this research contributes as stakeholders' information as one of the bases to implement tactical policies that improve teaching staff readiness for online distance teaching.

2. Literature Review

Before discussing this study, this section briefly defines the terms readiness, preparedness and capabilities. According to the Cambridge Advanced Learner's Dictionary, readiness is the willingness to prepare, or the state of being prepared for something [11]. A term that is similar to readiness is preparedness, but experts use these terms interchangeably. The same dictionary defines preparedness as the formal state of being prepared for a situation. By this definition, preparedness includes readiness and willingness. This study assumes that preparedness and readiness are synonymous.

However, experts differentiate between preparedness and competency. Competency in something, or competency in doing something, is the ability to do something well [11]. Similarly, the International Board of Standards for Training, Performance, and Instruction defines competency as knowledge, a skill or an attitude that enables one to effectively perform the activities or tasks of a given occupation or function to expected employment standards [12]. In developing an instrument to measure preparedness for e-learning, experts refer to the corresponding competency categories, or constructs, as the dimensions of preparedness. Gulbahar and Kalelioglu [13] defined e-instructors as instructors who might well be very experienced in teaching–learning contexts and even possess a high level of technology literacy. Being an experienced instructor and possessing advanced skills of using technology is necessary but not enough to lead to an instructor becoming an effective e-instructor.

Denis et al. [14] explain that competencies could be categorised as pedagogical, communicational, subject expertise and technological. Klein et al. [15] explain that the categories are professional foundations (communications, professional development, law and ethics, and credibility), planning and preparation, instructional methods and strategies (motivating, presenting, facilitating, questioning, clarifying and correcting, skill retention and transfer), assessment and evaluation, and management (managing the environment and

managing the appropriate use of technology). Lynch and Smith [16] categorise competencies as personal, pedagogical, technical, managerial and institutional.

The dimensions of university lecturers' (faculties') preparedness are linked to how they view their functions. Guasch et al. [17] identify the following specifications for every lecturer' functions/roles: (a) design/planning function, (b) social function to build a positive environment during the teaching/learning process in a virtual environment, (c) instructive function in their roles as facilitators and subject experts, (d) technological domain and (e) management domain. Therefore, lecturers require knowledge and skills to present content and facilitate learning by using technological tools and resources.

Research on how lecturers view e-learning readiness was carried out by Nwagwu [18]. With 240 lecturers from Nigerian universities as respondents, the study concluded that according to the opinion of lecturers, the readiness of society, funding, training, ICT-equipment, and e-learning content development were significant influencers on the readiness of Nigerian universities towards the adoption of e-learning [18]. The readiness of students and human resources were not found to be significant factors towards the adoption of e-learning.

Competent e-instructors are key to successful e-learning implementations and they should have the appropriate skills and experience for the effective implementation of e-learning and blended learning Gulbahar and Kalelioglu [13]. The study concluded that being an experienced instructor and possessing advanced skills of using technology is necessary but not enough to lead to an instructor becoming an effective e-instructor.

Ochogo et al. [19] examined the influence of lecturers' computing competence and preparedness for electronic learning (e-learning). The aim of the study was to investigate the influence of institutional support through providing training programs and funding on lecturers' preparedness to teach in an e-learning environment at the University of Nairobi. The study found no significant relationship between lecturers' preparedness for e-learning and the perceived effectiveness of the existing training program. Lecturers' preparedness was significantly influenced by training in software tools.

The COVID-19 pandemic has caused a rapid transition to online education around the globe. The adoption of e-learning systems during the pandemic is a difficult and challenging process [20], and will continue after the pandemic [21]. This emergency transition to e-learning and faculty development is different from regular transition that requires global collaboration, such as sharing published material [21]. Transition to e-learning is the whole process of change, the actual conversion of each course in an institution, including the training of faculty, and the faculty finalizing their courses and then migrating to the new online environment [22]. The author reported that even in normal condition, transition from face to face to e-learning is considerably time consuming and changes the faculty's role and teaching responsibilities [22].

Alqahtani et al. [20] investigated critical success factors for e-learning during COVID-19. They concluded that technology management, support from management, increased student awareness to use e-learning systems, and demanding a high level of information technology from instructors, students, and universities are the five most influential factors [20]. They highlight that the leading factor for improving the educational process during the pandemic is readiness for e-learning implementation, not how advanced the technology is.

3. The Method

3.1. Research Approach and Context

This research used a mixed-method approach—it collected and analysed both quantitative and qualitative data from respondents. Considering the scope, this research applied a case study design where lecturers from Indonesia were representative of the population and selected participants with varied backgrounds and experiences. Quantitative data were taken from Likert-based instruments to measure the respondent's perceptions by using deductive, logical thinking, and qualitative data were coded to discover their patterns. They

were then interpreted using deductive, logical thinking. In line with research mapping, as initiated by Saunders et al. [23], this research adopted pragmatism as a paradigm where qualitative and quantitative research should be compared to extract more useful information. It accommodates the more holistic data findings and triangulation since quantitative measurement would be completed alongside in-depth opinion as confirmation. The mixed-method approach has been satisfactorily practiced in education-based research [24–28]. Therefore, the collected and analysed data can be more reliable and qualified.

3.2. Participants

This research used voluntary and convenience sampling techniques. These techniques were chosen due to their simplicity, low cost and time investment, and the vast population available. This research focuses on instructors from universities in Indonesia, who hosted the e-learning classes. Relying on social media, this research petitioned participants during April 2020, when the pandemic began in Indonesia, by which time all universities had decided to host online learning. Table 1 summarises their demographic profiles. Jabodetabek is a term for Jakarta (the capital city in Java) and the surrounding cities, Bogor, Depok, Tangerang and Bekasi.

Table 1. Respondent Lecturer Demography.

Attribute	Category	N	Percentage
Location	Java Jabodetabek (the capital and adjacent cities)	10	9
	Java non-Jabodetabek	55	49
	Sumatra	19	17
	Sulawesi	19	17
	Other	7	6
Discipline	Social and Humanities	20	18
	Engineering	73	65
	Education	10	9
	Health	5	4
	Religion	4	4
E-learning Experience	Yes	71	63
	No	41	37

This research is confident that the demography is adequate and representative due to the large number of participants and good distribution. Most regions in Indonesia were captured, predominantly Java, which reflects the proportion of universities in Indonesia. Five disciplines are represented, with the majority of participants in engineering. Although 37% of respondents had no prior experience of teaching in an e-learning environment, this research leverages their perceptions to unveil instructors' readiness to teach in an e-learning environment for the first time.

3.3. Research Phases

The study was conducted in the following phases: literature search and review, problem formulation, research questions formulation, data collection and analysis, presentation of results and interpretation, and conclusion writing. Literature search and review were carried out using relevant digital libraries (e.g., ACM, Science Direct, and IEEE Xplore) and journals (e.g., Education and Information Technologies) related to online learning and online preparedness. The problem was formulated by reflecting on the researchers' experiences while facilitating online learning, specifically before and during the pandemic, and reviewing the literature. Based on the problem formulation, the research questions were proposed. Data collection was conducted online, and data analyses was conducted for both quantitative and qualitative data.

3.4. Research Instrument

This research relied on two basic instruments to measure the readiness of lecturers. It adapted the University of Toledo's [29] instructor readiness questionnaire and made appropriate adjustments to improve quantitative reliability. The study is comprised of four parts (dimensions): Basic Technical Skill; LMS Experience; Course Planning, Time Management, and Communication; Course Design. Each part has four items, except for the last, which has five items.

The instruments were delivered in questionnaires, using five-point Likert scales. The higher the scale, the more strongly the respondents agree with the statement (item). Descriptive statistics were derived from interpreting the collected data by calculating the average and deviation standard. Next, the qualitative data coding process was coded to find themes that reveal the lecturers' perspectives on challenges, motivation, instructional design, collaboration, teaching and learning strategies, available IT infrastructure and other potential themes. The questions are the following:

- Describe what you think, or feel, about your capacity as an educator during this pandemic.
- In responding to the current pandemic, please state three things about, or adjustments to, your teaching strategy.
- Name three online teaching challenges that you experienced.
- As a lecturer, what are your expectations of students while teaching during the pandemic?
- As a lecturer, what are your expectations from the management of the study program, or faculty, while teaching during the pandemic?

4. Results and Discussion

The following sections present the research findings to answer two research questions related to lecturers' readiness levels to conduct online classes during a pandemic and lecturers' expectations when participating in online distance education.

4.1. Instrument Reliability and Validity Tests

The reliability test checked the consistency of items after repeated trials. In comparison, the validity test was applied to test the validity of a questionnaire in the population. The reliability and validity tests were carried out using SPSS Version 24 software, and the reliability of each part of the questionnaire was tested first, then followed up by confirming the validity of the items in the corresponding part.

Table 2 shows the reliability and validity of the test results. It covers five metrics: Cronbach's Alpha (CA), Cronbach's Alpha Based on Standardized Items (CASI), the smallest Corrected Item-Total Correlation (CITC), the smallest Cronbach's Alpha if Item Deleted (CAID) and R-Table. The CA value ranges from 0 to 1, with higher values indicating greater internal consistency. A CA of 0.7 or higher is considered reliable. If the CITC and CAID values are higher than the R-Table value, each item in the questionnaire is reliable and valid.

Table 2. Reliability and Validity Tests of the Lecturer Readiness Questionnaire.

Part	CA [1]	CASI [2]	Lowest CITC [3]	Lowest CAID [4]	R-Table	Conclusion
Part A: Basic Technical Skills	0.888	0.897	0.705	0.717	0.1857	Reliable and valid
Part B: LMS Experience	0.844	0.847	0.619	0.766	0.1857	Reliable and valid
Parts C and D: Course Planning, Time Management and Communication	0.722	0.732	0.339	0.650	0.1857	Reliable and valid
Part E: Course Design	0.794	0.797	0.501	0.734	0.1857	Reliable and valid
Part A: Basic Technical Skills	0.888	0.897	0.705	0.717	0.1857	Reliable and valid

[1]—CA: Cronbach's Alpha; [2]—CASI: Cronbach's Alpha Based on Standardized Items; [3]—CITC: Corrected Item-Total Correlation; [4]—CAID: Cronbach's Alpha if Item Deleted

This research adopted five parts/dimensions of the instructor readiness assessment. The lecturer readiness questionnaire's reliability and validity test showed that parts A, B, and E are valid and reliable. However, parts C and D are not reliable because the CA values for parts C and D are 0.568 and 0.542, respectively, less than the accepted lower limit of 0.7. However, parts C and D are valid because for each item the value of CITC and CAID is greater than the R-Table value. This research found that PTC-06 (I feel more comfortable communicating through speech than through writing) is invalid and should be deleted. After combining parts C and D, and deleting the PTC-06 item, they become reliable and valid, and the analysis is based on this revised version. Table 2 shows a summary of the reliability and validity tests.

4.2. Quantitative Interpretation of Lecturers' Perspectives

This section elaborates on and discusses the findings related to the lecturers' perspectives on their readiness to teach online.

4.2.1. Correlation Analysis

By using Chi-square correlation analysis, the lecturers' readiness to teach online is closely related to the lecturers' level of convenience using the LMS to design online classes, facilitate students in the learning process and the lecturers' ability to communicate well through writing (LMS-01, LMS-02, PTC-02 and PTC-05).

4.2.2. Correspondence Analysis

Correspondence plots are carried out for each aspect of the question to obtain more accurate results. Below is a correspondence plot. To simplify the plot, item names are shortened to "A" for "BAS", "B" for "LMS", "C" for "PTC" and "D" for "DSG".

Based on the correspondence plots in Figures 1–4, it is concluded that lecturers who have taught online are well prepared to use the e-learning system, which includes time management, class planning and online class design. However, lecturers who previously only taught face-to-face (do not have online teaching experience) are less prepared for class planning, time management and online communication. Clustering (k-means) was applied to see the characteristics of lecturers in teaching online and Table 3 summarises the results.

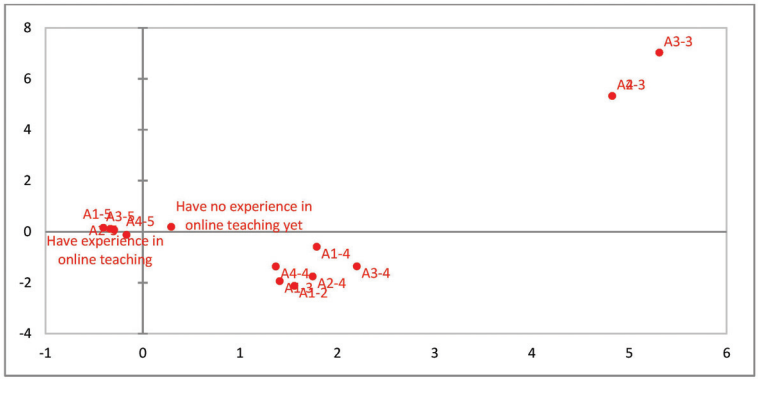

Figure 1. A correspondence plot of Part A (Basic Technical Skill).

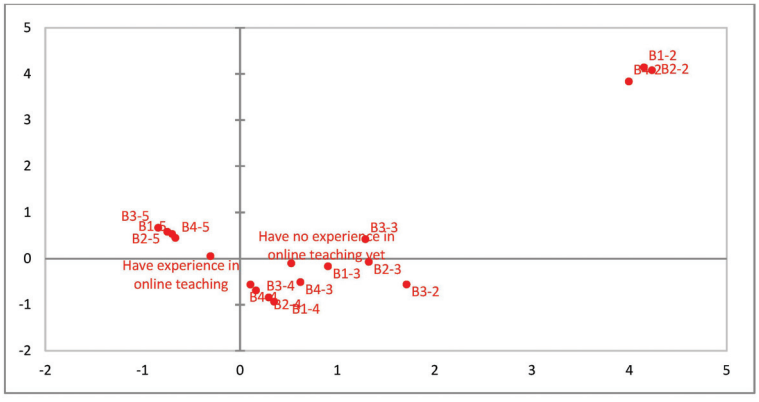

Figure 2. A correspondence plot of Part B (LMS Experience).

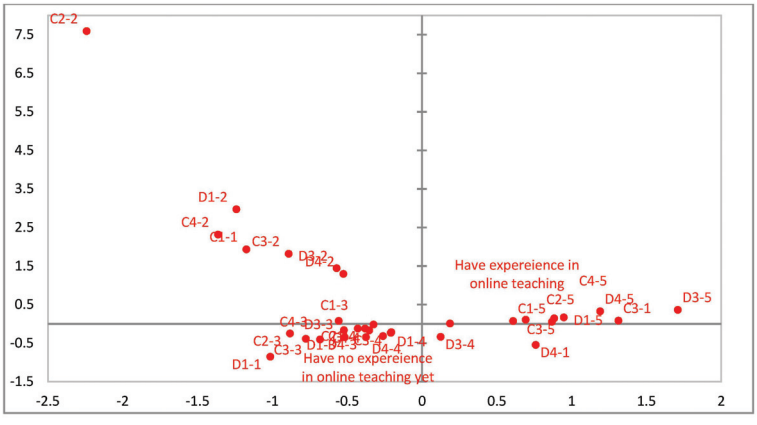

Figure 3. A correspondence plot of Parts C and D (Course Planning, Time Management and Communication).

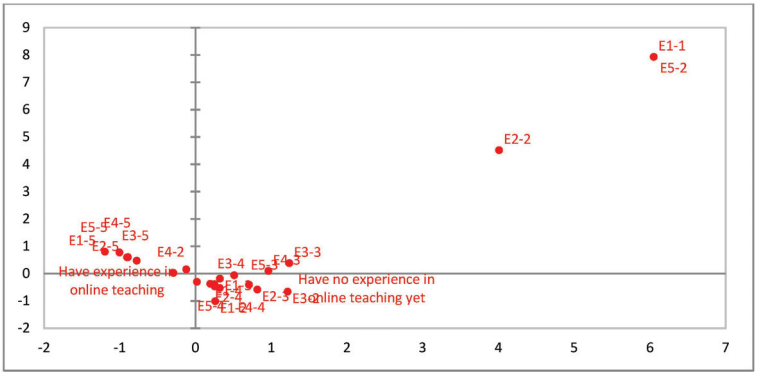

Figure 4. A correspondence plot of Part E (Course Design).

Table 3. Comparison between Lecturer's Clusters.

Issue	Lecturers Who Are Prepared for Online Teaching	Lecturers Who Are Less Prepared for Online Teaching
Have previous online teaching experience	Yes	No
Basic skills in operating electronic devices and LMS	Have good basic skills to operate electronic devices and LMS	Have basic skills to operate electronic devices (such as managing files and using browsers)
LMS usage	Already feel comfortable	Not ready
Class management and design	Have good skills to design classes and time management of the student learning process	Less prepared to design online classes and manage time.
Communication style	Capable of communicating online, both verbally and in writing (such as conveying feelings/affections)	Less ability to communicate via text or audio/video devices

Aspects that need to be considered so that lecturers are better prepared for online teaching are the ability to use the LMS correctly and express feelings/affections through writing, audio or video, which are weak points due to a lack of previous online teaching experience. Table 4 shows the complete scoring for each instrument.

Table 4. Faculty Online Teaching Readiness Survey.

Code	Indicator	SD	Mean	Cluster 1	Cluster 2
Do you have pre-pandemic online teaching experience?				Yes	No
	Basic Technical Skills (average 4.835)				
BAS-01	I can use office applications, such as Open Office, Microsoft Word and Microsoft PowerPoint.	0.492	4.786	5	5
BAS-02	I can perform file management on my computers, such as copying, moving, renaming and deleting files or folders.	0.407	4.848	5	5
BAS-03	I can send and receive emails and open and send email attachments.	0.349	4.884	5	5
BAS-04	I can use an Internet browser, such as Google Chrome, Firefox or Safari to search the Web and upload/download files and programmes.	0.429	4.821	5	5
	LMS Experience (average 4.230)				
LMS-01	I feel comfortable using an LMS (such as Moodle and Google Classroom) to build an online course.	0.824	4.295	5	4
LMS-02	I feel comfortable using features in the LMS to facilitate student learning.	0.748	4.313	5	4
LMS-03	I feel comfortable using LMS assessment tools to evaluate student performance.	0.738	4.179	5	4
LMS-04	I feel comfortable using the LMS to record student grades.	0.833	4.134	5	4
	Course Planning, Time Management and Communication (average 3.980)				
PTC-01	I am detail oriented.	0.725	4.277	5	4
PTC-02	I am good at organising teaching materials.	0.691	4.250	5	4
PTC-03	I expect online teaching to take more time than face-to-face instruction, and I am prepared for it.	1.009	3.991	4	4
PTC-04	I am willing to provide timely and constructive feedback on student performance.	0.774	4.152	4	4
PTC-05	I feel comfortable communicating through writing and can do it easily.	0.902	3.920	4	4
PTC-06	I feel more comfortable communicating through speech than through writing.	0.843	4.027	-	-
PTC-07	I feel comfortable conveying my personality and/or emotions through writing.	0.849	3.518	4	3
PTC-08	I feel comfortable conveying my personality and/or emotions through speaking (audio/video).	0.965	3.705	4	3
	Course Design (average 4.082)				
DSG-01	I feel comfortable writing measurable learning objectives based on Bloom's taxonomy.	0.781	3.857	4	4
DSG-02	I feel comfortable designing active learning activities that allow students to interact with their peers, instructors and course content.	0.646	4.205	4	4
DSG-03	I understand copyright law and fair use guidelines when using copyrighted materials.	0.741	4.250	4	4
DSG-04	I understand accessibility policies on student needs.	0.737	4.125	4	4
DSG-05	I know how to accommodate student needs.	0.716	3.973	4	4

4.2.3. Part A: Basic Technical Skill

Generally, this dimension was the best from the lecturer's perspectives. It indicates that lecturers have strong basic technical skills as a baseline to use e-learning platforms for online courses. Their strengths are shown by the five items as the most elected option, while the standard deviation was relatively low. Achievement in this dimension also became a meaningful foundation to encourage lecturers' digital literacy. This research did not find critically bad areas of concern since almost all lecturers have adequate basic technical skills, and most Indonesian people use mobile phones.

4.2.4. Part B: LMS Experience

All indicators have a score of 4.00 or more. This shows that lecturers are able to use LMS, with fast adaptation. Interestingly, some respondents claimed that they had no experience of online classes before the pandemic. This research argues that LMS platforms have good usability so that lecturers feel easy, comfortable and satisfied when using them. Moreover, most lecturers state their conformity when leveraging LMS as an assessment medium, not only for teaching agendas. In an open-question answer, out of 112 respondents, 12 and seven people out of 112 respondents stated that they used Zoom and Google Classroom as the LMS platforms, respectively.

4.2.5. Parts C and D: Course Planning, Time Management and Communication

Generally, this research captured a balance score distribution between 4 and 5. This research emphasis became a crucial issue since communication determines whether, and how, lecturers transfer knowledge, skills and inspire their students. This research argues that the pandemic occurred mid-semester, while the planning was done before the semester. Therefore, most lecturers can focus on migrating their course agenda from a physical class to an online class, but this research also highlights that the pandemic was unexpected, so most lecturers had a tactical solution by hosting online classes with low feasibility, and they did not have a strategic solution.

Statistically, item PTC-07 was the most significant challenge and is the lowest indicator (3.52). It shows that many lecturers stated their inability to express themselves through written media. This feeling became a significant challenge due to the large differentiation between communication styles in a physical class and an online class. In the physical classroom, the interaction between lecturer and student occurs by combining audio, visual and kinaesthetic methods, but online classes rely on written communication to minimise data transmissions since video generates much more data. Unfortunately, written messages can obscure real emotional feelings, such as when the lecturer expresses appreciation or disagreement.

Interestingly, an item on the readiness to spare the time to teach online had a score of 3.99. This indicates critical issues concerning the online class paradigm. This research identified that most lecturers thought that online classes required more time to compose a video storyboard, upload course material, decompose the online course scenario, monitor student activity and review the assignment. As stated by RL-29, a lecturer needed more time to determine the best method to assess student achievement. A similar complaint was expressed by RL-106 who felt confused about how to objectively measure student achievement. Several respondents revealed they had decided to revise course planning by switching from lectures to assignments during the pandemic.

Item PTC-08 (I feel comfortable conveying my personality and/or emotions through speaking (audio/video)) confirms the above-mentioned issues—it scored a relatively low 3.705 when compared with the other items. In contrast, respondents claimed that communication through written media was relatively easy, as captured in PTC-05 (I feel comfortable communicating through writing and can do it easily) with a score of 3.920. This research concludes that lecturers experienced difficulties in carrying out easy tasks. This could be due to the rapid transition to online as a result of the unexpected pandemic. Internet access is another challenge since some cities have poor internet connectivity, according to RL-81

and RL-86. This pushed the lecturers to choose synchronous online classes, while online classes relied on asynchronous internet access due to its instability.

4.2.6. Part E: Course Design

This dimension had an average score of 4.08, which reflects several challenging issues. First, this research found that lecturers' conformity to teach online was not optimised since they did not fully believe the learning goals could be achieved, which relates strongly to the third dimension. At the beginning of the semester, lecturers had set learning outcomes as a standardised goal that should be cascaded into the syllabus. Unfortunately, their designed syllabus had to be revised, especially the content, delivery and other course design attributes. This can lower lecturers' confidence about the previous syllabus and the achievement of its learning goals as well.

Fortunately, many elective LMS platforms can be leveraged to host online classes. They provide many useful features that accommodate lecturers' course design requirements. For example, some LMS platforms offer a submission menu that simplifies student assignment uploads and downloads by lecturers. As mentioned by RL-32, online classes should provide impetus to explore more advanced features, such as creating online attendance registers, online examinations or file sharing.

4.3. Qualitative Interpretation of Lecturers' Perspectives

Using a qualitative approach, this research captured lecturers' perceptions through open-ended questions embedded in the survey, after the quantitative instruments. The results are presented in the following table.

This research captured meaningful statements by lecturers by using codification. Tagging was used to count, and cluster responses based on their similarity. Based on the results of the thematic coding, six themes are the most dominant. If a theme had a greater frequency, more lecturers had similar perceptions, making it a more essential issue. Table 5 shows the codification summary.

Table 5. The Most Dominant Challenges Faced by Lecturers.

Theme of Challenges	Frequency	Example of Responses
Internet connection and internet fee (quota) The biggest challenge was the unstable internet connection. More than 55% of lecturers mentioned unstable internet access, especially experienced by students who live in remote areas. Internet connection problems interfere with the teaching and learning process. Lack of equipment support was also an obstacle for some students. More than 23% thought that online learning disadvantages less fortunate students due to internet quotas.	55.36%	"The internet connection was poor, students have network access constraints so they cannot attend lectures, and the quota was limited." "Lack of equipment for underprivileged students." "The internet quota for students is limited, especially those who live in rural areas where the network/signal is sometimes slow, thus limiting video conferencing." "Additional fees for internet quota."
Course delivery and teaching strategies More than 23% of respondents acknowledged the challenges of delivering effective, creative, and relevant material and matching subject characteristics so that they were easy to understand. Lecturers recognised that online learning requires different teaching skills.	32.2%	"Must carefully explain so that it is more effective and easier to digest by students." "Creativity in delivering relevant material." "Teaching online is different from face to face, more difficult and requires high commitment." "Less optimal for lesson that require practice in the laboratory." "To create and describe the formula formulas and their applications are rather complicated."

Table 5. *Cont.*

Theme of Challenges	Frequency	Example of Responses
Evaluation Some lecturers experienced serious challenges in evaluating learning outcomes and processes in the four most dominant aspects: an exam model that measures understanding well; administering and monitoring learning progress; encouraging students to maintain integrity and honesty; and monitoring the assessment process to avoid cheating.	16.96%	"Still looking for an evaluation method that truly describes the abilities of students." "More difficult to check and provide feedback on student work." "Proper administration of exams, exam models." "Difficult to control the student working process, whether doing it themselves or cheating."
Time constraints Compared with the setting before the Covid-19 pandemic, lecturers felt that it took longer to prepare lecture materials. They admitted that they were constrained by having to manage their time to adapt to the new teaching modes.	11.6%	"I need more time to prepare lecture materials so that the objectives and learning goals are conveyed by students even though the limitation of non-verbal communication." "It is difficult to manage time, during WFH . . . need time to adapt."
Monitoring Lecturers found it challenging to ascertain whether the learning process occurs, monitor understanding and control whether tasks completed by the student or by someone else.	9.8%	"Difficult to control whether students do their work or copy someone else's work." "Cannot be monitored whether students are involved in the learning process or not." "Still difficult to assess the level of understanding in discussion forums."
Motivating students Lecturers admitted they were challenged in helping to improve students' readiness to undergo online learning. Lecturers were challenged in motivating students to focus on, and being, actively involved in the learning process. Lecturers saw the gap in student readiness.	9.8%	"Provide support and enthusiasm to learn online, overcome boredom, maintain student focus." "Difficult to make students learn actively, through discussion." "Not all students are ready for online lectures."

Lecturers' challenges can be divided into two dimensions: (1) the unstable internet connection and additional expenses for internet usage that burden students (55.36%) and (2) lecturers are more challenged in carrying out their roles (71.16%). Lecturers are challenged in preparing teaching materials, delivering the courses, monitoring student progress and engagement, evaluating learning and helping students maintain motivation and engagement, which forces them to invest more time and effort.

5. Implications

5.1. Theoretical Implications

This research has revealed empirical results on lecturers' readiness for teaching online courses. Interesting facts were found that have theoretical implications. Lecturers' readiness was relatively high (4 to 5 on the scale) although they had a medium level of experience in e-learning (63%). This implies that experience does not automatically make someone ready to conduct online courses. This research found that most of the lecturers received training to host online classes. This opportunity accelerated their knowledge and skills to allow them to be better prepared when running online classes during the pandemic. This situation reflects a study conducted by Reyes-Chua et al. [6] who said that a lack of faculty member training to use e-learning classrooms is an essential problem in delivering online courses during the pandemic. E-learning will become a necessity in education. Instructors must increase their capabilities to run e-learning well. Besides being ready to run e-learning, lecturers must also help students to be ready to study in an e-learning environment.

This research also addresses two frequent issues that lecturers face: unstable internet access and self-management. These issues are coherent with students' critical problems, as

mentioned by Ebner et al. [5]. These authors noticed that students could suffer depression and anxiety due to unfavourable study environments at home, which lead to a lack of self-management. Similar to Ebner et al. [5], this research classifies both issues as barriers that should be tracked when assessing students' readiness. It suggests that both these frequent issues become barriers for lecturers and students. Online collaborative learning, for example, using a discussion board, can bring students and lecturers closer, and thus reduce anxiety [5]. Lecturers need training to improve their preparedness to conduct e-learning and to help students become ready to learn in an e-learning environment. Caliskan et al. [30] suggested that universities should have distance education centre to help lecturers tackle technical problems. Internet access has been the most frequent issue raised by lecturers. It indicates the lack of the readiness of ICT infrastructure. This is consistent with the study conducted by Nwagwu (2020), that found ICT-equipment readiness to be one of the most significant factors influencing lecturers' opinions about the readiness of universities to adopt e-learning.

This research actualized a mixed-method approach to enable more holistic findings. It also accommodated the comparison to ensure data reliability and validity, especially in data interpretation. Therefore, this research has proved the mixed-method approach's strength as claimed by [24–26,28].

5.2. Practical Implications

This subsection focuses on emphasising the necessary LMS features that should be developed to encourage lecturers' readiness. Lecturers' readiness and confidence to use LMS for online courses will increase by implementing appropriate features. First, lecturers require time-management features. They are physically separated from each other, so they may forget many tasks. When lecturers start their daily activities, they should find their tasks and complete them with less interaction with others. Therefore, their skill to maintain schedules should be improved. Second, this research highlights the importance of notification features that alert lecturers of any updated information in an online course, such as edited assignments, new comments in a forum or submission reminders. This should reduce miscommunication because the lack of information is due to poor LMS design. Third, statistics tracking should be developed to measure lecturers' LMS adaptation rate. This will enable the university to adjust the LMS structure and content to enhance readiness. Fourth, all LMS business processes should be measured, including the amount of data transmitted. People usually buy prepaid internet packages, such as 1 GB/month and 50 GB/month in Indonesia. It implies their internet access is limited, so that data transmission during online classes should be minimised to ensure their continuity during online learning. Furthermore, findings in this research should become an essential consideration for university management and government to encourage the quality and effectiveness of online learning during the COVID-19 pandemic. For example, university management can formulate appropriate standards for online learning by accommodating lecturers' readiness and teaching methods.

6. Conclusions

This research provides empirical findings on lecturers' readiness to conduct online courses. Most lecturers had adequate readiness to host online classes during the COVID-19 pandemic. The study combined quantitative and qualitative data gathered from university lecturers in Indonesia. For quantitative measurements, this research adopted the instructor readiness questionnaire of the University of Toledo [29] and made appropriate adjustments to improve reliability. It comprised four parts (dimensions): (1) Basic Technical Skill; (2) LMS Experience; (3) Course Planning, Time Management and Communication; (4) Course Design. Using descriptive statistics, their scores (out of 5.00) were 4.834, 4.835, 4.230, 3.980 and 4.082, respectively. Lecturers' readiness was relatively high (4 to 5 on the scale) although they had a medium level of experience in e-learning (63%) before the

pandemic that accelerated their knowledge and skill, allowing them to be better prepared when running online classes during the pandemic.

This research also highlights two frequent issues that lecturers face: unstable internet access and self-management. It suggests that these two issues become barriers for lecturers and students. This research provides several solutions to overcome these issues by proposing features in LMS. With appropriate features, lecturers will be better prepared and more confident when using LMS for online courses.

7. Outlook for Future Research

After performing a quantitative and qualitative assessment on lecturers' readiness, this research makes several recommendations for future research. First, this research suggests using a broader and more diverse sample to provide a more holistic view of lecturers in Indonesia, especially lecturers with new experiences. To obtain a broader and more diverse sample, this research proposes snowball and purposive sampling techniques. These techniques can be used by associations of lecturers or social networking to reach greater potential populations.

Second, this research captures lecturers' views about unstable internet access. Interestingly, internet access was not an instrument in lecturers' readiness since the instruments were created in European countries with stable internet access. Therefore, this research suggests that future research should adjust the readiness model and instrument in line with Information Technology (IT) infrastructure, such as the university's IT service and internet access. Moreover, lecturers and students are in separate locations, so their interaction was influenced by IT infrastructure.

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Article

Assessing Undergraduate Students' e-Learning Competencies: A Case Study of Higher Education Context in Indonesia

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Abstract: The COVID-19 pandemic that occurred in early 2020 around the world has implications for Indonesia's education sector. This pandemic led to the Indonesian government policy to study from home at all academic levels using a distance learning approach. Studies on e-learning preparedness in Indonesia involving more comprehensive samples of universities during the pandemic are still limited. This study extended samples from several public and private universities in Indonesia to get a broader picture of e-learning readiness in various faculties with diverse university online learning cultures. This study used Rasch analysis to determine the validity and reliability of the instrument and differential item functioning (DIF) analysis to identify responses based on students' demographic profiles. The results show that most students were ready to study online, but a few were not ready. Moreover, the results show significant differences in students' e-learning readiness based on the academic year at university, the field of study, the level of organizational e-learning culture of the university, gender, and region. This work provides an insight into student readiness to study online, especially in higher education in Indonesia. The article presents the implications of online learning practices in universities and recommendations for future e-learning research.

Keywords: e-learning; students' e-learning preparedness; e-learning competency; Rasch analysis; online learning

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1. Introduction

The COVID-19 pandemic has provided momentum for the growth of online learning in Indonesia at all education levels, from kindergarten [1], primary school [2], junior high school [3], senior high school [4], to higher education [5,6]. In this pandemic, the application of online learning is inevitable. The Indonesian government supports these online learning activities by issuing policies to carry out learning activities from home [7]. In carrying out suitable online learning activities, students need to have the readiness to learn online [8–11]. The level of online learning readiness can affect students' interaction [12], level of emotional intelligence [13], satisfaction, and motivation [14–16] in the online learning environment. Students' preparedness for undertaking e-learning is essential to produce effective learning performance [17].

Before the COVID-19 pandemic, several universities in Indonesia had initiated learning innovations by implementing online learning (either fully online learning or blended learning). One of the universities that implements complete online learning in Indonesia is the Open University called Universitas Terbuka (UT). The learning process at this university is carried out through learning assistance services using Tuton (learning assistance through the Learning Management System asynchronously), TTM (face-to-face learning assistance), and Tuweb (learning assistance through online meetings/synchronously) [18]. UT students have a very high level of learning readiness compared to students who have never undertaken online learning [19]. The high level of UT students' online learning readiness is strongly influenced by self-regulation, self-directed learners, and the ability

to use various kinds of software [20]. One of the universities that applies blended learning is the Universitas Indonesia. Students in this tertiary institution have a high level of online learning readiness in terms of interaction in online communities [21]. Junus et al. [21] stated that students were ready to use technology to help the learning process. However, the ability to interact meaningfully in a discourse needs to be improved. Junus et al. [21] suggest that the institutions train students to communicate effectively with other learners and lecturers. The two universities mentioned above show that a high level of online learning readiness is possible because lecturers and students are familiar with the online learning environment. However, from 4741 universities in Indonesia, there are only 15–20 universities that have implemented e-learning [22–24]. This indicates that the online learning culture in Indonesian universities is still weak, and this situation undoubtedly affects students' readiness to participate in online learning.

At the end of 2019, the coronavirus outbreak (COVID-19) was first reported in Wuhan, China. This COVID-19 epidemic has spread and infected people throughout the world. Noting the alarming spread and severity rate, the World Health Organization (WHO), through Director-General Tedros Adhanom Ghebreyesus, established the situation as a pandemic as of 11 March 2020 [25,26]. The coronavirus pandemic has implications for various sectors of life in multiple countries, including Indonesia. The education sector in Indonesia is one of the areas affected by the coronavirus pandemic. Although the culture of online learning organizations in universities in Indonesia was still uneven at the onset of the pandemic, the Minister of Education and Culture of Indonesia, Nadiem Makarim, established a study from home (SFH) policy. Through circular number 36962/MPK.A/HK/2020, online learning and working from home were established to prevent the spread of the coronavirus disease) [7].

This pandemic situation led to the question of student readiness at tertiary institutions in conducting online learning activities. Several studies with regard to readiness to study online in higher education during the COVID-19 pandemic in Indonesia have been carried out. Widodo et al. [27] conducted a study on students at the University of Mataram. The results of his research [27] indicate that the level of student learning readiness is still lacking. This is due to a lack of mastery of online media, lack of training, limited costs, and poor internet connections [27]. Most students expect online learning to stop and for learning to return to face-to-face arrangements. Meladina and Zaswita [28] also found that the level of online learning readiness at Fort De Kock University was still lacking. Students felt they did not understand the material, were less focused on learning, and lacked interaction [28]. Meanwhile, Sulistyohati [29] found that students of the Faculty of Engineering, Cikarang University, were ready to study online, provided that universities prepared an e-learning system and socialized it.

In previous studies [19–21,27–29], a questionnaire was given to students in a subject area at a university in Indonesia. They also showed that technical constraints are the main factor for students' unpreparedness to learn online. It is essential to determine exactly how diverse factors, like the academic year at university, the field of study, the e-learning culture of a university, gender, and region, relate to student e-learning preparedness. This study expanded the sample to several public and private universities with various fields of study to get a broader picture of e-learning readiness in various faculties with diverse university online learning cultures. Research questions that guided the investigation of student readiness to study online at the university level were as follows:

1. What is the level of student preparedness to study online in the higher education context in Indonesia during a pandemic?
2. Are there any significant differences in student readiness to learn online during pandemics based on the year of study, the field of study, the level of e-learning culture at a university, student gender, and region?

To answer the research questions, we investigated student readiness for e-learning at tertiary institutions in Indonesia. This study used a cross-sectional quantitative survey method. We collected the data from a sample of 482 undergraduate students using the e-learning competencies (EC) questionnaire. Data analysis used the Rasch model measurement to determine the validity and reliability of the instrument and differential item functioning (DIF) analysis to identify responses based on student demographic profiles. The findings in this study are expected to improve the effectiveness of student performance in online learning environments in tertiary institutions. This article consists of several parts. Following the background section, the second section contains a literature review on e-learning, student preparedness, and factors affecting online learning implementation. The third section outlines the research questions to be answered in this study. The fourth section includes the methodology used in this study and discussion and recommendations are presented in the final section.

2. Literature Review

2.1. E-Learning Types and Implementation

E-learning is a learning method that uses information and communication technology to convey information/material for education [30]. Some other terms widely used for learning methods include virtual learning, online learning, online computer-based training (CBT), and internet-based training (IBT) [31,32]. There are two types of interactions in online learning, namely synchronous interactions and asynchronous interactions. Asynchronous communication, facilitated by media such as e-mail or discussion forums, allows student interaction even though participants cannot go online simultaneously. Synchronous interaction, supported by media such as video conferencing and chat and communication, is carried out by participants simultaneously online. During the COVID-19 pandemic, learning interactions were not undertaken face-to-face. Instead, both types of interaction in the online learning methods mentioned above were used with technology from various platforms. Likewise, in universities in Indonesia during the pandemic, the learning process was carried out through learning management system (LMS) devices such as Moodle or Google Classroom [33–35]. The material is given in interactive activities online through various online platforms such as Zoom, Google Meet, and Microsoft Teams [36–40]. The learning resources provided are varied, such as interactive videos, animations, interactive quizzes, and online discussions.

E-learning as a learning method has several advantages. According to Arkorful and Abaidoo [40], e-learning can facilitate communication/delivery of knowledge and motivate students to interact with each other, exchange information/ideas, and respect different perspectives in discussion activities. The e-learning method, associated with a clear and structured pedagogical approach, can also influence motivation, participation, autonomy, concepts, outcomes, and grades of students [41]. However, despite the benefits of e-learning, according to Omidinia, Masrom, and Selamat [42], there are still many challenges, especially in developing countries. The challenges of e-learning in developing countries include the lack of e-learning infrastructures such as computers, electricity, and skills. Also, the activeness of students participating in interactive learning is still low [42]. According to Bhuasiri et al. [43] in [32], barriers to e-learning in developing countries are due to the lack of investment in the necessary technology, such as hardware, software licensing, equipment maintenance, development of learning and training materials, and management support. From the students' perspective, some challenges affecting online learning include poor internet connectivity, inadequate computer laboratories, limited computers/laptops, inadequate computer skills, and lack of time to interact with lecturers and fellow students [44].

The implementation of e-learning in higher education in Indonesia, as a developing country, is currently facing many obstacles. According to Kusumo et al. [45], the challenges in implementing e-learning in Indonesia are low levels of learning independence, connection problems, and difficulties in producing teaching material. This statement is consistent

with the statement by Aboderin [46] in [47] that internet connectivity and the availability of tools (computers and software) are obstacles that affect the implementation of online learning in developing countries.

2.2. Student Preparedness

The determination of students' level of preparedness to learn online can be used as a basis for building a fair and effective e-learning system [14,48]. Studies on online learning readiness among students have been conducted over the last ten years. The studies show that the results of online learning readiness can vary with time, depending on the institution or instrument used for assessment [49].

Studies on student preparedness to learn online in Indonesia are still few. From 2015 to 2020, there were ten studies published regarding students' readiness in tertiary institutions and three studies for high schools in Indonesia. Seven of them found that students were at a suitably prepared level, and six studies found that students were not ready to learn online.

Suwarsono [50] conducted a student readiness study for level 2 and 3 students from a private university's engineering faculty. This study looked for significant differences based on academic level/year and gender. The measured dimensions consisted of self-directed learning readiness and technical readiness. The study found that the average student was at the ready level, with the technical readiness dimension having the highest level of preparedness and the lowest being self-directed learning readiness. There were no significant differences found based on academic year or gender. Junus et al. [21] conducted a study of the preparedness of freshmen students to study online. The results of this study indicated that students were ready to use technology to help the learning process. However, they still needed to develop self-discipline, learning skills, and an active role in the learning environment. The and Usagawa [51] compared online learning readiness between Indonesian and Myanmarese students. The study found significant differences based on the learning environment, lecturers' roles, university facilities, possible benefits of e-learning, and confidence in readiness. In these two groups of samples, there were no significant differences found in the learner's background. Overall, the results of this study indicated that both Indonesian and Myanmarese students were ready for e-learning. However, facilities at both universities were still inadequate to implement and support e-learning effectively. Sulistyohati [29] showed that students at the Faculty of Engineering of Cikarang University were ready to study online. Still, an e-learning system was required that could meet student needs for learning and assignments. A study by Firdaus et al. [52] concluded that students of the Faculty of Tarbiyah and Teacher Training at Wonosobo were ready to participate in online learning activities. However, it was necessary to manage good learning online and pay attention to network aspects because not all students had good internet access. An investigation by Ramadiani et al. [53] of junior and senior high school students in Samarinda showed that students were ready to learn online. Still, they hoped to add the use of games and music to online learning activities. A study by Dwiyanti et al. [8] for junior high school students in Denpasar showed that students were at the ready level overall. However, in the dimension of independent learning, students were judged to be not ready. Therefore, it is necessary to encourage students to communicate actively in online learning, especially shy students.

Several studies have also shown students' unpreparedness to learn online. Purwandani [54], in her study, found that students of one of the Informatics Study Programs in Jakarta were not ready because e-learning was considered problematic as they were not used to interacting with e-learning. Also, the presentation of interactive material content was not yet available. She recommended holding training sessions or workshops for e-learning users to build awareness of how to use e-learning to improve the quality of learning [54]. Mahardika and Ningtyas [55] measured online learning readiness in semester four and six students of the Teaching and Education Faculty in Malang. They found that students needed effective learning methods to maximize the delivery of material. Meladina [28] showed that students at Fort De Kock University found it challenging to undertake

online learning due to signal constraints, internet costs, lack of understanding of and focus on the material provided, and lack of interaction. Research conducted by Widodo et al. [27] showed that students' learning readiness at the University of Mataram was still lacking due to technical constraints, such as lack of mastery of online media, lack of training, limited costs, and difficulties in accessing the internet. Meanwhile, Saintika et al. [56] showed that students in the Central Java region found it difficult to learn independently. Furthermore, students' interest in learning online is still minimal. Ramadan et al. [57] found that high school students need more profound guidance about the benefits and easiness of using e-learning.

Previous studies show that technical constraints are the main factor for students' unpreparedness to learn online. Furthermore, adding interactive content, games, and music can increase students' readiness to learn online.

2.3. Factors Affecting Online Learning Implementation

Varying levels of student online learning readiness can affect the implementation of online learning activities. Factors such as gender, the student's year of study, the field of study, the level of organizational culture for e-learning, and the region can influence online learning activities.

In terms of the gender aspect, previous studies found that, in general, there were no significant differences in level, motivation, and satisfaction between men and women [58].

Nevertheless, the use of LMS resources showed a significant difference. In the wiki display and uploaded documents, the level of disturbance related to students' social lives perceived by men was higher than that perceived by women [58]. This finding is consistent with the results of Elango et al. [59]. They found significant differences between men and women concerning the relevance of the content and delivery of teaching materials, web use, online interactions, course compliance, and trust in the system [59]. Ünal et al. [49] found that women were more enthusiastic about using e-mail, learning management, and file management tools. Pingle [60] found that male students showed better readiness in collaborative activities than female students in terms of technological information skills, collaborative learning, independent learning, and reflective learning. This finding is the inverse of that of the research conducted by Johnson [61]. He found that women communicated more, had a more significant social presence, were more satisfied with the course, viewed the course as more valuable, and showed slightly better performance than men. Morante et al. [62] also found that female students were more involved in the learning community and achieved better learning outcomes.

Regarding the semester/academic year of the student, first-year students need more attention in the communication process, and they also need the provision of suitable teaching materials [63]. Second- and third-year students need further training in e-learning [49]. Fourth-year students are better able to adapt to e-learning and its components [49,64]. In one study, they showed greater independence and were more motivated to learn online [10]. Hung et al. [10] further found that the third- and fourth-year students had higher self-efficacy in online communication than the first- and second-year students on the same course. The students studied were taking courses on life chemistry, calculus, statistics, Taiwan ecology, and an introduction to environmental protection.

With regard to the field of study/knowledge students were part of, the author of [60] found that students in the University of Mumbai from the art department had better reflection abilities in learning compared to students majoring in commerce. Another study conducted by Adams et al. [47] in a public higher education institution in Malaysia found that students from the social sciences major had a higher preference for e-mail communication than medical students. Also, social science students were more confident when posting questions in online discussions [47].

The level of organizational culture in e-learning is one aspect that is still very rare in research on student readiness in online learning. Literature discussing learners' independent learning styles and habits and the evolution of learning styles and patterns is still limited [65]. When implementing e-learning strategies, organizational culture can act as a facilitator and preventive factor that influences the e-learning process [66]. In e-learning, organizational culture is related to the learning culture, changing learning habits, making students understand how to learn [67], and making both teachers and students accustomed to developing and using e-learning systems [68]. A culture for good/high online learning is not natural and does not just happen. Students need to go through a process of habituation that may continue for months or even years. Online study habits enrich the online learning experience, so that students are better prepared to study online. The lack of e-learning implementation in Indonesian tertiary institutions causes the online learning culture of Indonesian students to remain at a low level.

With regard to the influence of regions, Blankenship and Atkinson [48] found no significant differences in the self-management of learning and comfort with non-face-to-face communication between students who live in cities and rural areas. Likewise, in a study conducted by Thakkar and Joshi [69], the authors found no significant differences in e-learning attitudes between rural and urban students. However, a survey conducted by Elnakeeb and Khalifa [70] found that students who lived in urban areas had higher computer/internet self-efficacy and higher efficiency in online communication than those living in rural areas. Asfar and Zainuddin [71] also found that students from urban areas tended to be more independent in learning than those from rural areas.

This research is different from previous studies of student preparedness. In an earlier study, a survey was carried out on student respondents who had undergone online lectures for some time, both fully online and blended. In contrast to this earlier study, in our present study the questionnaire was given to students who had never undertaken online lectures, neither fully online nor blended. In connection with the emergence of the COVID-19 pandemic, each campus issued a policy on online learning. Our survey was conducted at the beginning of the pandemic. Many students were suddenly confronted with a distance learning environment and did not yet have much experience attending online lectures.

3. Method

3.1. Context of the Study

This study used a cross-sectional quantitative survey method. The questionnaires were distributed online and lecturers in West Java and Banten, Indonesia, were contacted to distribute the questionnaire links among their students. The provinces of West Java and Banten, Indonesia, were chosen as they have a higher number of tertiary institutions and students than other provinces [72]. Besides the tertiary institutions in the West Java and Banten provinces, they have diverse e-learning cultures, from high to low levels of e-learning culture [72]. The questionnaire was available for students online for two weeks, from 22 March 2020 to 5 April 2020, and was filled out by 482 students from 22 universities with various fields of study in West Java and Banten, Indonesia. Participation was voluntary and anonymous. The demographic profiles of the participants are illustrated in Table 1.

3.2. Instrumentation

The questionnaire used was the e-learning competencies scale developed by Parkes and Reading [17], which was adapted by Junus et al. [21]. There are 58 items in three dimensions as follows:

1. E-Learning management and e-learning environment, 24 items.
2. Interaction with teaching materials, 13 items.
3. Interaction with e-learning community, 21 items.

Table 1. Demographic characteristics of participants.

Category	Total	Percentage (%)
Gender		
Male	336	69.71
Female	146	30.29
Level of e-learning culture at the university		
High	117	24.27
Middle	57	11.83
Low	308	63.90
Field of study		
Economics	30	6.22
Sociology, politics, and humanities (SPH)	17	3.53
Education	10	2.07
Engineering	397	82.37
Health	28	5.81
Region		
Urban	286	59.34
Rural	196	40.66
Year of study		
First year	78	16.18
Second year	114	23.65
Third year	241	50.00
Four year	49	10.17
Age		
18 years and below	31	6.43
19 years	130	26.97
20 years	136	28.22
21 years	97	20.12
22 years	51	10.58
23 years	24	4.95
24 years and above	13	2.70

Responses to all items used a five-point Likert scale, from very poorly prepared (1) to very ready (5). Only one answer was allowed per item. We used the Rasch measurement model software WINSTEPS, version 3.90.2, to determine the instrument's validity and reliability. The Rasch model analysis was used because it is a powerful assessment tool for overcoming the circular dependence observed in classical test theory [73]. The Rasch model can provide objective measurements in a variety of settings [73,74]. Rasch analysis can calibrate item difficulty and person ability simultaneously through residual analysis [73]. In this study, we visualized the possibility of answering questions correctly or supporting statements through the item characteristic curve (ICC), the test information function (TIF), and the differential item functioning. WINSTEPS software transforms raw data (Likert-type data) of item difficulties and person abilities mathematically. The internal reliability scores shown in Table 2 refer to the fit statistics that determine the overall quality of the EC scale.

Table 2. Reliability of item and person.

	Mean Logit	Standard Deviation	Separation	Reliability	Cronbach's Alpha
Item	0.00	0.41	5.98	0.97	
Person	0.99	1.20	5.33	0.97	0.97

Based on Table 2, the item reliability index (0.97) was classified as "excellent" [75]. This index shows that the respondents responded well to the items given, or, in other words, the items were able to define the dimension variables very well. Item separation shows how important an item is in determining issues that are easy (very ready) and severe

(less ready). The value of item separation (5.98) indicates that the questionnaire items could group student readiness in learning online.

The person reliability index (0.97) indicated that the consistency of responses from respondents was "excellent" [75]. This index means that the EC scale could discriminate between respondents very well. The person separation value was (5.33), rounded up to 5. The strata person value was 7, reflecting mixed ability, which indicates the representation of the strength of students taking the test. The Cronbach's alpha index (0.97) was classified as "excellent". This index shows that the interaction between 482 respondents and 58 items was high. We can say that this measurement scale is an instrument with high reliability because it has perfect internal consistency [47]. We can also see the high interaction from the item fit curve in Figure 1. The curve shows that the level of item suitability for empirical data was appropriate, based on items that were fit to the model (red line). However, there were two items of misfit seen from point x that were not on the ideal line curve (red line). An item may "misfit" if there is an inconsistency in the respondent's answer [75]. This is because the item is very easy (very negative logit score) or complicated (logit score is too large) [75]. Therefore, these two items had to be reviewed.

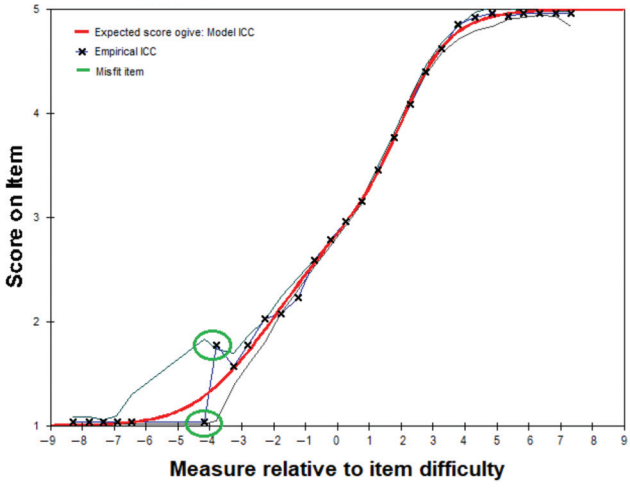

Figure 1. Expected score item characteristic curve (ICC). Every student has online learning readiness. Each online learning readiness is grouped into readiness ranges. Within each readiness range, one marker is plotted. The x-axis represents the average readiness of the students in that range. If there are no students, there is no marker. The y-axis represents the average of the responses scored by the students.

4. Results

This section presents the findings based on the Rasch analysis. First, student readiness for blended learning was analyzed. The overall findings indicate that students were ready to study online. Furthermore, we used DIF analysis to identify responses based on student demographic profiles (i.e., the academic year at university, fields of study, e-learning university culture, gender, and region). The DIF analysis informs various responses based on demographic groups' characteristics, the most appropriate analytical method for this study [47]. The findings presented in the next paragraph answer the research questions.

Based on Table 3, the mean value was above 0.00 logit and was in the range of 0.5 to 1.5, which means that the random size had excellent conditions, so the items were neither too easy nor too difficult. The standard deviation (SD) values were appropriate overall, and each dimension was in the range of −1.9 to 1.9, which means the data had a logical estimate (the data were ordered by model). We can conclude that, overall, students were ready to study online.

Table 3. Results for student online learning readiness.

	Mean	Standard Deviation
E-learning competencies (overall)	+0.99	1.20
E-learning management and e-learning environment	+0.96	1.36
Interaction with teaching materials	+0.98	1.43
Interaction with e-learning community	+1.29	1.56

The information function graph in Figure 2 shows two peaks of optimal information obtained for individuals with less preparedness and for more prepared individuals. Some individuals were less ready (negative peaks) to learn online, but more students were ready to undertake online learning (positive peaks).

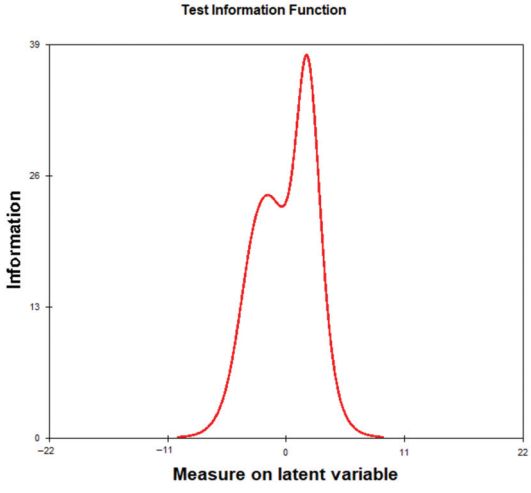

Figure 2. Test information function.

We also checked the suitability of items from this instrument. According to Boone et al. [76] in [75], there are three criteria that can be used to assess the suitability of an item:

- The outfit mean square (MNSQ) value is in the range $0.5 < \text{MNSQ} < 1.5$.
  Using this first requirement, two items were misfit, namely item A6 (learning/working in a disciplined and scheduled manner) and item B3 (presenting content in various formats (video, audio, etc.)). The outfit MNSQ values for the two items were 1.82 and 1.52.
- The outfit z-standard (ZSTD) value is in the range $-2.0 < \text{ZSTD} < +2.0$.
  The ZSTD value is greatly affected by sample size. In this study, the sample size was large enough that the ZSTD value was always above 3. Therefore, this condition was not used as a reference in this study.
- The point mean correlation (Pt Mean Corr) value is in the range $0.4 <$ Pt Mean Corr < 0.85.
  The instrument met the third requirement, there being no items that had a Pt Mean Corr value under 0.4 or over 0.85. All items were eligible to be used for measurement.

The differences in readiness for learning online for students' academic year at university, the field of study, the level of e-learning culture at the university, gender, and region were analyzed using DIF analysis. The analysis for each demographic category mentioned above is described in the next paragraph.

Figure 3 illustrates the DIF plot based on student year of study. The DIF plot identified six items that have significant differences ($p > 0.05$). Items A1 (uploading/downloading

information and learning resources) and A7 (adapting to learning styles that fit the e-learning environment) show that the first-year students had better abilities than those in the second, third, and fourth years of study. Based on item A15 (making a priority scale in doing assignments that must be completed simultaneously), fourth-year students could prioritize tasks better compared to lower-level students. For items A4 (integrating various software applications to create a product) and B3 (presenting content in multiple formats (video, audio, etc.)), first-year and second-year students were better able to integrate various applications and present content in multiple formats. However, they were less able to manage their time to attend online classes regularly (item C17) compared to third-year and fourth-year students.

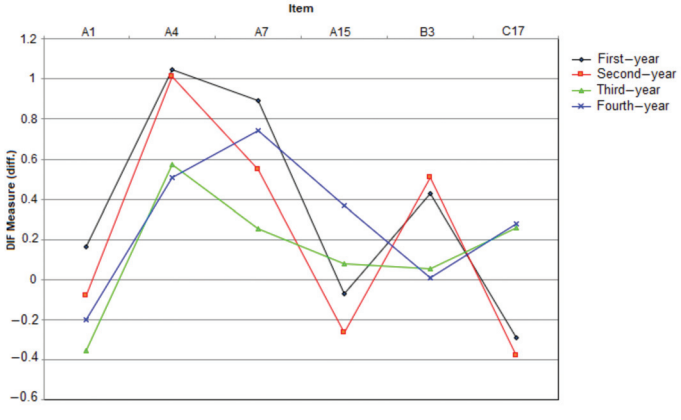

Figure 3. Person DIF plot according to student academic years of college.

The DIF plot based on the student field of study in Figure 4 identifies ten items with significant differences ($p > 0.05$). In item A2 (using search engines effectively), students in the health field can better use a capable search engine compared to students from other areas of study. In item A4, A5, and C17, students in economics were better able to integrate various software applications (item A4), use technology for understanding the formation of knowledge (item A5), and manage time (item C17) compared to students in other study fields. In item A13 (doing work independently), students in economics and engineering were more self-reliant than the students in other areas of study. In item A19 (doing appropriate strategic planning to complete the task), students in the SPH field were less able to make strategic plans than students in other study fields. However, students in the SPH fields can collaborate collaboratively to form knowledge (item C7). They do more willing to have their ideas discussed and criticized (item C8) than students in another field. In item A20 (evaluating yourself as a positive learner), the students in the education field think more positively in self-assessment than those in other study fields. However, students in the education field make less effort to initiate interaction with other members in the learning community (item C20) than other fields.

Figure 5 depicts the DIF plot for the university e-learning culture level. The DIF plot shows 11 items that had significant differences ($p > 0.05$). For item A1 (uploading/downloading information and learning resources), students with high and medium levels of university e-learning culture were more capable than students with low levels of university e-learning culture. However, students with a low-level e-learning culture could implement problem-solving strategies (item A14). They were better able to respond responsibly to other participants (item C1) and arrange a time to attend online classes regularly (item C17). Students with high levels of e-learning culture were more ready to study/work in a disciplined and scheduled manner (item A6) than students with medium and low university e-learning culture levels. This student group was also more autonomous in

doing their assignments (item A13), more prepared to present content in various formats (video, audio, etc.) (item B3), and more ready to collaborate to form knowledge (item C7). Students with a moderate level of university e-learning culture had a better ability to adapt to learning styles appropriate to the e-learning environment (item A7). They were better at showing/demonstrating knowledge through LMSs (item A12) and associating previous and new learned experiences (item B1).

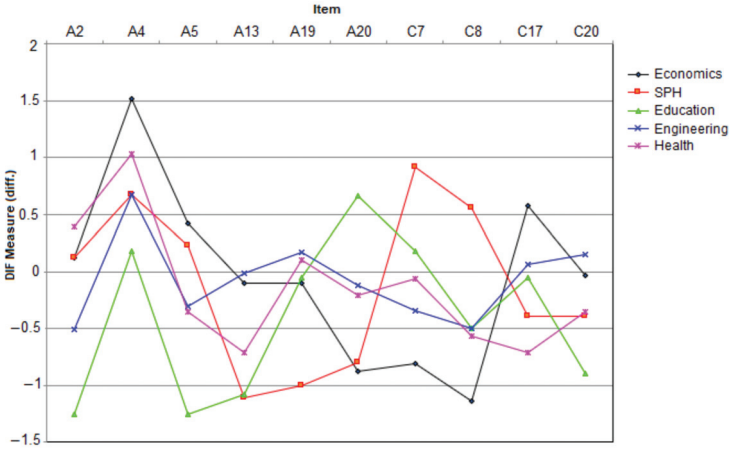

Figure 4. Person differential item functioning (DIF) plot according to student field of study.

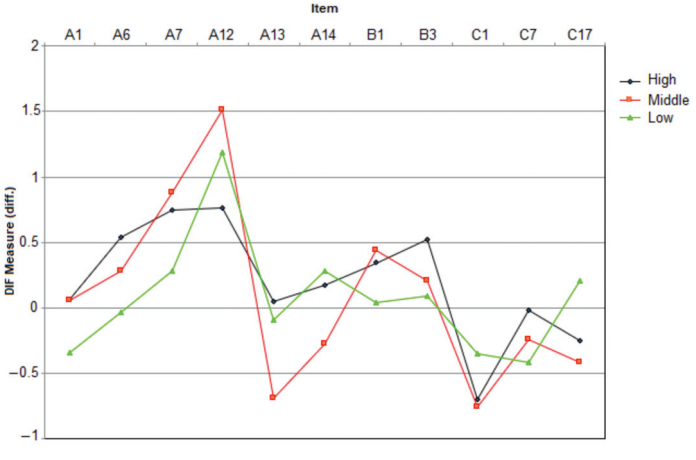

Figure 5. Person DIF plot according to university e-learning culture level.

In Figure 6, the DIF plot shows four items that had significant differences ($p > 0.05$) based on gender. For items A18 (applying logical steps to solve problems related to computer use), B12 (looking for information outside (not limited to online communities and available technology)), and C8 (willing to have their ideas challenged), female students had higher skills than male students. However, for item C17 (managing time to attend online classes regularly), male students could manage their time better than female students. Female students were more open-minded and organized, whereas male students had advantages in time management.

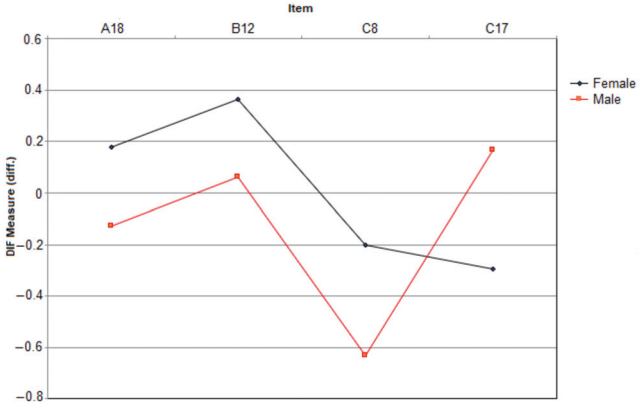

Figure 6. Person DIF plot according to student gender.

The DIF plot for the regions where students studied online is illustrated in Figure 7. The DIF plot identified four items as having significant differences ($p > 0.05$). Students who lived in rural areas were better at uploading/downloading information and learning resources (item A1) than students who lived in urban areas. This student group was also better able to work collaboratively to form knowledge (item C7) and contribute by proposing new ideas in discussions (item C10). Meanwhile, groups of students who lived in urban areas responded better to other participants (item C1) than those living in rural areas. The results reveal that living in rural areas did not dampen students' enthusiasm to learn online independently and collaboratively.

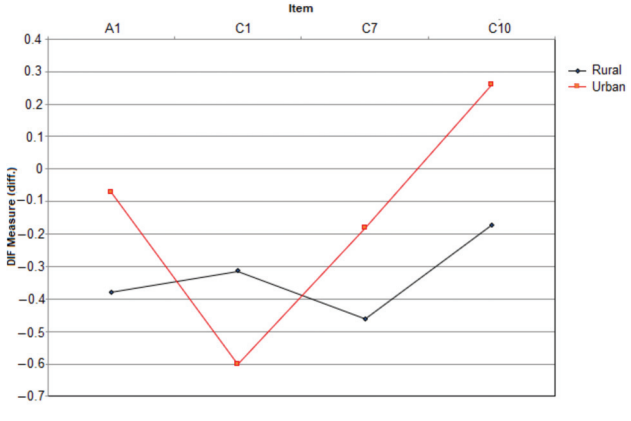

Figure 7. Person DIF plot according to student region.

5. Findings and Discussion

This study aimed to investigate the level of student readiness to learn online during a pandemic in Indonesia. Furthermore, this study assessed significant differences in student preparedness in online learning based on the academic year at university, the field of study, the level of e-learning culture at the university, gender, and region. The results show that some individuals were still less ready to learn online, even though more students were prepared to engage in online learning. Based on the questionnaire results, the obstacles students often experienced in learning online were the internet network, laziness, and discomfort following online meetings. Also, it took a while to understand the material described and there was interference from the surrounding environment. We recommend

that lecturers anticipate learning methods by increasing asynchronous activities over synchronous activities.

The DIF analysis shows significant differences for the demographic profiles of student online learning readiness. Demographic profiles were analyzed based on the year of study, field of study, the level of e-learning culture at the university, gender, and region. With regard to the students' academic year, the results of this study revealed that each group across the four years encountered obstacles in online learning readiness. First-year students had the advantage in accessing information and learning resources and adapting to learning styles in the e-learning environment. First- and second-year students could integrate various applications and present content in multiple formats. Third- and fourth-year students were more disciplined in managing their time to attend online classes. Fourth-year students were better able to make a priority scale for doing assignments that had to be completed simultaneously. Based on these findings, first- and second-year students' ability to access learning resources and adapt proves that they were passionate about learning new things. Therefore, we recommend that lecturers provide various learning resources and present interactive content [77] for the first- and second-year students to maintain students' enthusiasm. For students in years three and four, it is necessary to analyze whether students' discipline in managing time affects learning quality. Lecturers need to optimize their teaching time with learning activities to increase student creativity and understanding [78,79].

With regard to students' field of study, the study results revealed that students from all groups in education had no difficulty in interacting with teaching material. However, there were significant differences in management and the e-learning environment and interactions with the e-learning community. Students from the health sciences were better able to use search engines effectively. Students from the economics group could better use and integrate various applications and technologies and manage their time. Students from the economics and engineering fields were more independent in conducting online learning activities. Students from the sociology, politics, and humanities course could collaborate to shape new knowledge and were more willing to have their ideas challenged. However, this group of students could not make strategic plans related to completing assignments in learning. Students from the education sciences had positive thoughts in self-assessment but made less effort to initiate interactions with other members of the learning community. According to previous studies, metacognitive scaffolding can support planning, monitoring, and self-evaluation during the completion of learning tasks [80–82]. We recommend that lecturers provide metacognitive scaffolding assistance [83] to help students make strategic plans to complete their learning assignments. Additionally, we suggest that lecturers add collaborative learning activities to enhance interaction skills in the learning community. This recommendation is based on Laal and Ghodsi's [84] statement that collaborative learning can improve social competence.

With regard to organizational culture in e-learning, the study results revealed 11 items with significant differences. Students from universities with a high level of e-learning culture were more disciplined and had better schedules. This student group was also more independent in completing assignments while working collaboratively to form new knowledge. This student group was also better able to present content in various formats. Students from universities with high and medium levels of e-learning culture could better access information and learning resources. Students from universities with a moderate level of e-learning culture could better adapt to learning styles in an online learning environment. They could better interpret their knowledge through LMSs and were better able to associate their prior experience and the knowledge they had just learned. Students from universities with a low level of e-learning culture could respond responsibly to comments from other discussion participants and better manage their time to attend online classes. Based on these findings, a higher level of e-learning culture in a university provides the ability to adapt to learning styles in an online learning environment and be more independent in

learning. We recommend that virtual learning should be given greater attention than face-to-face learning or that blended learning should be used.

From the student gender perspective, there were significant differences between female and male students. Female students could better implement logical steps to solve problems, search for information without being limited to the online community, and were more willing to have their ideas challenged. Male students were better able to manage time to attend online classes. In accordance with these findings, we recommend that lecturers provide collaborative learning with heterogeneous groupings [85,86] of women and men. These groupings would allow students to help each other so that each member's shortcomings, both male and female, could be minimized.

From the perspective of student regions, there were significant differences between students who lived in urban areas and those living in rural areas. Students who lived in rural areas could access information and learning resources, collaborate to form knowledge, and contribute better by proposing new ideas in online discussions. On the other hand, students who lived in urban areas could respond responsibly to comments in online reviews. This reveals that the enthusiasm to study online, both independently and collaboratively, of rural students is not dampened by their location. The results follow Cjeda, Prieba et al., Philpott et al., and Renes and Strange in [87], who clarified that students from rural areas have a strong desire to learn and complete higher education. A previous study conducted by the authors of the current study [83] recommend that lecturers provide motivation scaffolding assistance to manage student motivation to study online until the end of the semester.

6. Conclusions

After 20 years, several Indonesian researchers in online learning are still struggling to advance Indonesian education by implementing distance education. The COVID-19 pandemic finally provided the momentum for the growth of online learning in Indonesia at all educational levels. In this pandemic, the application of online learning is inevitable. However, this has not been accompanied by student readiness to engage in online learning.

The results of this study reveal the level of students' e-learning readiness during the pandemic in Indonesia, showing the importance of familiarizing students with online learning activities—studying online needs to become a new organizational culture in higher education. Developing an e-learning culture is essential because, in the DIF analysis, this demographic factor showed the most prominent significant differences. In addition to the organizational culture of e-learning at the university, there were also substantial differences in other demographic factors—namely, the field of study, students' academic year at the university, region, and gender.

To improve students' online learning readiness, we recommend several improvements that should be prepared by lecturers: (1) preparing various learning resources, presenting interactive content, and optimizing teaching time with learning activities to increase creativity and understanding; (2) providing metacognitive scaffolding support to help students design strategic plans for task completion; (3) adding collaborative learning activities with heterogeneous groups; and (4) providing motivation scaffolding assistance to manage student motivation. With regard to theory, we suggest revisiting items and adjusting them to conditions in Indonesia to avoid confusion among students in responding to questions.

Apart from those findings, this study also has limitations. First, this research did not cover all universities in Indonesia. Out of the 4741 tertiary institutions in Indonesia, students from only 22 tertiary institutions in West Java and Banten, Indonesia, participated. Therefore, future studies need to cover all tertiary institutions in Indonesia to get a larger sample size so that the data can be grouped in more detail. Also, it is essential to note the readiness of online learning in terms of lecturers and campus management. Second, this research did not discuss the level of internet connectivity in each region. The regions considered in this study were only rural and urban. Future studies with a larger sample size could expand the region data. Furthermore, it is necessary to specify the level of

internet connectivity in terms of students' economic backgrounds and the infrastructure they must access.

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Some Web-Based Experiences from Flipped Classroom Techniques in AEC Modules during the COVID-19 Lockdown

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Abstract: The classroom closure during the first semester of 2020 entailed decisive changes in higher education. Universities have become more digital in both the availability of e-resources and pervasive devices and how students communicate with lecturers and classmates. Learners adapted their study habits with a growing role of self-paced, internet-based strategies. Some flipped learning approaches have proven their efficacy under the remote-teaching physical constraints. This study aimed to appraise the outcomes from the implementation of various web-based, learning-aid tools on flipped teaching approaches in engineering modules. The open educational resources (OER) performed satisfactorily during the lockdown period in three universities from two countries with similar higher education models. Such resources encompassed classroom response systems and web-based exercise repositories, designed for diverse purposes such as autonomous learning, self-correction, flipped classroom, peer assessment, and guided study. The acquired experiences reveal that OER helped students to enhance their engagement, reach the deeper levels of the cone of learning, and widen their range of learning abilities. This procedure is easily attainable for architecture, engineering, and construction (AEC) courses and lifelong learning settings. Feedback from students, instructors' perceptions, and learning outcomes show the suitability and effectiveness of the web-based learning assistant procedure presented here.

Keywords: web-based learning; COVID-19 lockdown; flipped classroom; architecture-engineering and construction (AEC); blended learning; lifelong learning; meaningful learning

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1. Introduction

During the first months of 2020, universities all around the world had to face a sudden shift to online learning, due to lockdown, as a consequence of the COVID-19 global pandemic. Since this situation overcame with no time for preparing, the teaching resources, nor the technological means that online teaching implies, it can be argued that, in general, universities were not prepared to face this challenge and a huge effort had to be made by institutions and lecturers in order to handle teaching in the most satisfactory way.

Moore and Kearsley [1] defined online teaching as a planned learning that takes place in a different location where it is taught and other authors [2–4] made a distinction between the online synchronous teaching (real-time interaction) and the online asynchronous teaching (no real-time interaction). It is clear, nowadays, that the World Wide Web (WWW) not only facilitates asynchronous learning, allowing anytime and anywhere learning, but it also makes synchronous teaching by means of virtual meetings using video-calls easier [5]. The WWW provides a wide range of teaching possibilities that have been exploited intensely during more than two decades [6,7], and nowadays, it is hard to imagine higher education without its use [8]. Nevertheless, these tools are usually combined with other

traditional teaching methods, such as master classes and problem-focused sessions, which are particularly relevant in the context of many engineering courses. For example, it is worth mentioning the work by Manseur and Zohra that analyzed the performance of synchronous distance programs in Electric Engineering and Mathematics at West Florida University [9]. In the context of the global pandemic motivated by COVID-19, the use of online tools has sharply increased for obvious reasons, pushing lecturers to adapt their teaching strategies from one day to the next.

There is a wide variety of published research on the factors that influence learning achievement, ranging from physical parameters, such as classroom design, lighting, air quality, and temperature [10], to instruments or techniques that affect advanced levels of the learning pyramid [11]. The debate is even more complex about the advantages and disadvantages, benefits and weaknesses of the use of digital resources in higher education. Considering that electronic resources have undergone a transformation in university teaching and management [12,13]. These include learning management systems, mobile devices, and multimedia and interactive digital resources [14–16]. In this sense, educational websites are an effective way to achieve learning results such as checking, applying, putting into practice, analyzing, and even evaluating [17]. On the one hand, they facilitate students to learn at their own pace through electronic devices that they usually handle daily and with great dexterity [18,19]. On the other hand, they contribute to collaboration among universities as an internationalization effort [20,21].

Higher education has performed such a significant effort to implement Open CourseWare (OCW) or Massive Open Online Courses (MOOC) that has led to an attractive alternative for autonomous learning in webpages such as miriadax.net or coursera.org. However, most of the students leave courses after the first two or three lessons [22–24]. In addition, web-based learning has shown several advantages such as economics of scale, novel instructional methods, or flexible scheduling [25]. Among them, the possibility of overcoming barriers of distance has been of special interest during the COVID-19 pandemic situation [26]. Moreover, web-based learning became an attractive alternative for training during several months in most of the developed countries. During this period, the use of online means became essential for education, and a large number of materials, mainly videos and documentation, have been created and submitted to the internet. Thus, web-based learning materials have helped students and professionals to make the best use of their possibilities and improve their lifelong learning resources. In addition, web-based learning provides the learner with greater control over the learning process, schedules, and environment, allowing them to select multiple and varied learning opportunities. This individual learning could be of higher impact in the long term, given that self-motivation is the starting point of the learning process. Nevertheless, in order to achieve meaningful learning, some interaction is needed, and several drawbacks must be considered such as social isolation, responding to the real individual need, cost associated with developing, poor institutional programs, and the use of technology for the sake of technology [25,27]. Some other questions, such as the comparison of face-to-face learning, will always remain in the grey area, though there is no doubt that web-based learning has become relevant in these pandemic days and that the study of the best performance of the use of these methods is of great interest for lecturers and institutions [28].

The global sanitary crisis has boosted the digital transformation in many organizations, ranging from the sanitary field and industry to higher education [29]. Some digital transformation goals are to better serve customers and increase efficiency in processes. Thus, the migration of all paper and manual record-keeping into electronic files is still an ongoing process. Indeed, university policies are struggling to maintain a competitive edge, which is even more concerning when looking at the declining figures of incoming students. The closure of classrooms also entailed a large variety of changes in teaching strategies all around the world. The pandemic disrupted some assumptions of the teaching-learning process in higher education. Some higher education teaching frameworks previously es-

tablished are not guaranteed to function from now. The pure lecture model may no longer be an acceptable teaching pedagogy, as the rise of technology has arrived to stay [30].

The impact of the pandemic on higher education is still open for debate, and guidelines, experiences, and recommendations are increasingly emerging [31,32]. Web-based learning frameworks have gained presence during the development of digital transformation of universities [28,33]. As students are digital natives, it appears necessary to identify their perspective on the use of technology in the academic context, as well as with what purpose and operations students use the technologies, and to understand what their expectations are [26,34]. At the same time, it seems attainable to harness the benefits of digital media to communicate with them and guide their training. One interesting technique is the inquiry-based learning by using the so-called Immediate Response Systems (IRS)—or Student Response Systems (SRS) or Classroom Response Systems (CRS) [35–37]. These include elements such as the development of a positive relation with failure, objectivity, and continuous assessment as usual targets. They also introduce breakpoints during impartations to recall student attention and focus on key aspects of the lessons [38,39].

Diverse studies focused on evaluating the readiness of lecturers and the feasibility of LMS [40,41], others on collecting students' perceptions [42–44], on analyzing the impact of the online format on studying at home [44,45], on learning achievements [46,47], and on the efficiency of flipped teaching methods [44,48–52]. It appears that blended learning methods have suffered less than other teaching approaches during this sudden shift to remote teaching [51]. However, lecturers had to harness the best of flipped teaching and adapt it to a completely virtual context [44,49–52]. Other studies addressed the social impact of the pandemic crisis on the professional careers [53] and the lecturer's role [54], as well as the relationship between lecturers and learners [55]. Nevertheless, these are currently open fields for debate [56].

This study aims to appraise the outcomes from implementing various web-based learning-aid tools on flipped teaching approaches in engineering modules: the use of CRS, web-based repositories of problems and exercises, pre-recorded videos, and a problem-based learning approach for technological Master's engineering courses.

This study collects both lecturers' and students' perceptions and feedback with the aim of implementing further teaching measures. The information gathered comprises lecturers' perceptions, final grades, learning outcomes, feedback from online questionnaires delivered to students, as well as individual and group interviews.

2. Methodology

This study belongs to a collaborative project carried out by professors of the Universidad Politécnica de Madrid (UPM, Madrid, Spain), Universidad de Jaén (UJA, Linares, Spain) and Universidad de Piura (UDEP, Piura, Perú). The scope was to share techniques, methods, resources, and strategies for home and classroom learning in accordance with the United Nations Educational, Scientific and Cultural Organization (UNESCO) recommendation in promoting and reinforcing international cooperation in open educational resources (OER) [33]. The project focuses on applying innovative methods in higher education since digital technology and remote instruction are stepping ahead of face-to-face teaching [57]. The methodology aims at helping students to improve their learning of some key concepts of structural analysis, construction management, and operations research, although it is easily implementable in courses of other AEC disciplines.

This work builds on a renewed boost of a merged learning technique under the convergence between distance and face-to-face learning for undergraduate students of fundamental subjects in civil engineering [58]. It focuses on the use of digital resources for integrating their autonomous homework with classroom involvement and aims to swap passive class time for just-in-time teaching, give quality time classes, improve achievements, and enhance the instructor's role [28]. Thus, the application of OER contributes to increasing the number of e-resources available to the community following the current digital transformation trend undertaken by universities [33,59]. Some essential features of

the OER described are scalability, third-party availability, and transferability. In this regard, other AEC teaching units holding these modules can either use or adapt these contents as needed. Such a repository can also be reshaped as an e-resource for lifelong learning experiences, through which alumni can refresh or update some technical concepts over the years [60].

Learning Management Systems (LMS) have been increasingly used in higher education, albeit played a noticeable role during the lockdown period. Furthermore, some tools such as CRS—also called Immediate Response Systems (IRS)—, repositories of web-based interactive problems and videos have proven effective for calling student engagement and prompting them for active learning [37].

On the one hand, formative assessment is admitted to enhancing learners' achievement based on seeking success through failure [61–63]. Nevertheless, this methodology must address three well spotted challenges: (1) how to be effective in promoting meaningful learning, (2) how to tailor grading practices that promote personal improvement rather than competition, and (3) assessment feedback may cause a negative impact on low-achieving students, who are prone to seem to be unable to learn and may become discouraged [59,60]. In this regard, the CRS approach allows an instructor to collect feedback immediately and relies on the individual discretion, as most students are reluctant to speak up and engage in large groups. CRS may become a useful ingredient of the question-driven instruction (QDI) approach, occasionally used together with traditional teaching practice, instead of the classical transmit-and-test classroom model [64,65].

The methodology applied in this project aims at leveraging students' digital skills, boosting their active participation in remote teaching and assessing their learning. The target is to improve learning outcomes for both undergraduate and graduate engineering students. This study explores some results from the application of various student response systems in the classroom (SRS, IRS or CRS), namely Kahoot!, Socrative and Mentimeter.

On the other hand, the web-based tools aim to boost students' receptive and productive skills while learning the principles and the elusive concepts of construction-related subjects. A large percentage of students encounter difficulties in acquiring the knowledge of the basic principles of behavior of some usual structural typologies related to civil engineering constructions.

The OER described here were intended to enhance students' capabilities and spatial reasoning skills for envisaging the physical meaning of some intricate underlying concepts. The learning aid approach presented here encompasses a repository of interactive exercises and problems, written in HTML5, CSS and JavaScript, and is based on a problem-solving strategy. This tool is also adequate for self-correction, self-assessment, flipped teaching, guided study, and peer assessment, among other features [66,67]. This e-learning tool boasted good performance and acceptance during the confinement period at both UPM and UJA.

The indicators considered include the students' perception of the usefulness and benefits of the system employed, the agreement between expectation and system performance, satisfaction upon using the web-based systems, and the users' readiness to continue using the system in future courses.

This study also handled diverse control variables such as the teaching modality (synchronous or asynchronous), the course type (fundamental or technological, undergraduate or graduate), the instructor's predisposition and readiness to innovate, and previous experience with educational innovation, among others.

The students were surveyed twice during the semester and invited to participate in either individual or group interviews. Survey results provided quantitative data about student usage of digital technology, their purposes, the ways they did, and for what tasks. The interviews and observed classes provided valuable information around their reasons to do so.

2.1. Classroom Response Systems (CRS, SRS or IRS)

The changes in higher education have involved significant changes in the learning-teaching system, starting from the lecturer and reaching the students. Universities have encouraged the teaching staff to introduce modifications in the traditional teaching techniques. One of the main issues in AEC and science, technology, engineering, and mathematics (STEM) disciplines is the use of new methodologies and technology in the evaluation tasks, seeking to enhance the motivation of the students. This is a key aspect because there is a direct relation between the motivation of the students and their results. Since the 2017–2018 academic year, the assessment of Construction Management combined both the traditional methodology with some gamification approach based on Kahoot, Socrative, and others. These apps allow performing questionnaires in the classroom in real time. Moreover, the answers of the students can also be evaluated in real time, and after each question, a ranking of the students is shown. This permits the lecturer to focus on the main points of the lesson as well as breaking the monotony of the lecture at any time the lecture considers. In order to promote the daily study of the modules, a certain percentage of the final mark was obtained through the analysis of the Kahoot! tests. The influence of introducing such techniques, in the motivation towards the modules, was assessed by a test whose results can be seen in Figure 1.

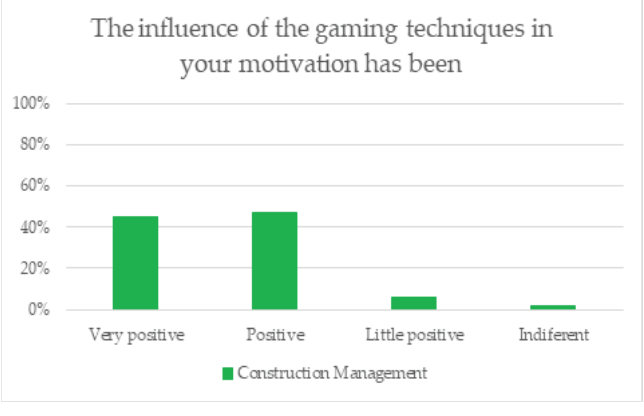

Figure 1. Results of the final survey regarding the influence of inquiry-based learning techniques introduced.

Therefore, some gamification methods were used before the COVID-19 lockdown and these previous experiences served as an approach to what was needed after the pandemic situation. At the time of writing, many implementations have been included in the modules Construction Management in the Bachelor's degree in Civil Engineering and Smart Construction: BIM in the Master's degree in Civil Engineering. However, the perception is that Kahoot! was already known and several new options, such as Socrative and Mentimeter, helped to improve the motivation during the lockdown. Mentimeter works in a similar way, although it features several new options such as the one shown in Figure 2 that help lecturers to promote student participation.

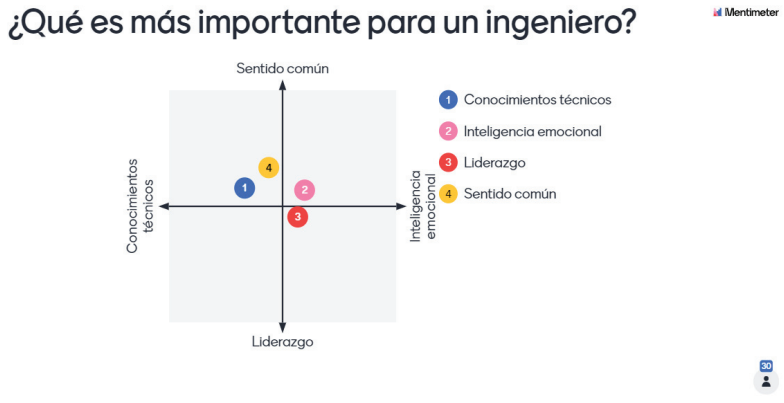

Figure 2. Mentimeter slide with 30 participants in Spanish with the open question: What skill is the most important for a Civil Engineer? and the answers: 1 Technical knowledge, 2 Emotional intelligence, 3 Leadership skills, 4 Common sense.

Some other tools were implemented during the lockdown given that there was not any possibility of student visits to construction sites. This activity was performed twice during the semester every academic year. Thus, this activity was substituted by the use of videos related to the construction processes and the management. In the same sense, Computer Laboratory activities in which the students learn how to use construction related software were also substituted by video-lectures. The main problem that the teaching staff had to face was that it was difficult to follow the assessment and the student could not see all the videos prepared for that aim. In such a sense, the use of Edpuzzle was of special interest as it permits inserting questions in the video sequentially. Thus, the students had to answer all the questions and the lecturer could see if they had seen it completely. After that, some exercises to put in practice, and the content of the video, were also proposed and marked for each of the activities.

2.2. Problem-Based Learning (PBL) and Classroom Response Systems (CRS) Strategies

PBL and CRS strategies were also designed with the aim of getting students to participate in knowledge reworking activities, as well as allowing them to get involved in real situations. Engineers use mathematics to describe and interpret situations, but find it difficult to identify, in the context of their work, the mathematics they have learned and envisage their physical implications.

The modules included in this study focus on practical and professional issues that students need to attain. This justifies that most classes are technologically oriented so students should achieve a variety of competences by means of a sequence of problems, projects, and challenges with increasing complexity. In this regard, the web tools presented can be properly applied in problem-based teaching practices [8]. Pre-recorded videos and the repositories of both online quizzes and interactive problems on Strength of materials, Structural analysis, Construction management and Operations research are intended to be used with the problem-based model.

2.3. Web-Based Strategies

This line of action aims to boost students' receptive and productive skills while learning the fundamentals of Structural Analysis. It draws on the difficulties encountered by a large percentage of the students in understanding the implications of the principles that govern the response of some simple structures with widespread application in civil engineering constructions.

The formal object encompasses the combination of web-based tools with other open educational resources (OER), which altogether contribute to enlarging the availability of the so-called e-textbooks [14], necessary for the blended learning models implemented at these teaching units. The web-based material focuses on enhancing students' spatial reasoning skills for envisaging the actual response of simple structures. This entails mastering concepts such as equilibrium, bending stiffness, force transmission, support conditions, moving loads, worst load combinations, and envelopes of response features. As a result, learners become able to identify the critical sections of a given structure and envisage the most unfavorable loading for a given structure.

The resource is freely available through any web browser. It encompasses a collection of pre-recorded videos with classes given by lecturers, a collection of pre-set Socrative tests and a repository of interactive problems and exercises written in HTML and JavaScript to be accessed through any web browser.

The pre-recorded videos harness the availability of the digital tablets as a modern version of the classical blackboard [68,69]. It is useful for both on-campus and remote teaching [70]. Figure 3 shows a snapshot of a screen during a class. Teaching with a tablet allows the lecturer to add colors and images easily, save the successive screens and voice, export them to digital format, and generate new e-resources. Tablets facilitate instructors the benefits of an attractive electronic lecture presentation and the ability to signal and jot down directly on the screen, remark relevant aspects, or respond to student queries. These are enormous advantages compared with the classical blackboard sessions. Besides, the tablet has proven to be a useful and effective device during the lockdown period for both tutorials and student follow-up. It has changed the classroom interaction and communication between students as well as collaborative work [71]. At the same time, it has become highly adequate for ubiquitous teaching [13].

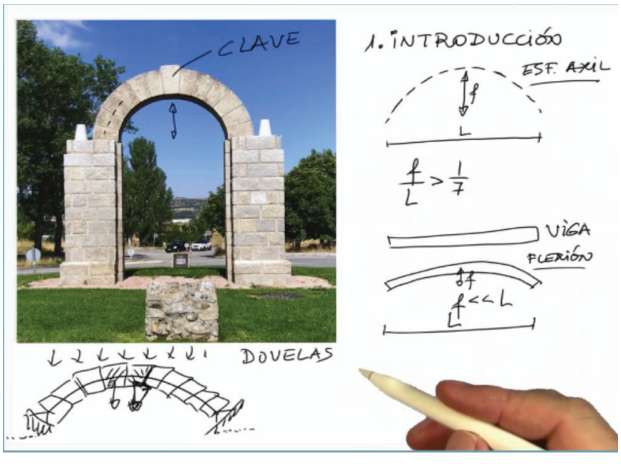

Figure 3. Snapshot of a class taught with a tablet and the digital pencil.

The collection of web-based problems and exercises has increased the OER available to learners and has been conceived for a multitasking purpose: autonomous learning, self-correction, flipped teaching, peer assessment and guided study. Its topic sequence follows the course syllabus development. Once the user has accessed, chosen the preferred language (Spanish or English) and topic, and selected an interactive exercise, they begin an interactive exercise. Then, a sequence starts, consisting of the statement, solving triggering, solution, rubric, and feedback provided by the system. The user can set the desired data values for physical and mechanical properties of the structural system, i.e., the span lengths, support conditions, load types and values, and flexural stiffness. Then the structural system is plotted on the screen.

After setting the problem data, upon clicking a "calculate" button, the system returns the numerical results and graphic output for the user-defined data. The latter draws on the advanced features of JavaScript and jQuery.

The user can browse back and forth throughout the diverse parts of the exercise, which includes a help context providing hints, remarks and comments at each solving step. Besides, these web pages may include some links to complementary short videos. In this way, the users can take ownership of his/her learning. To date, students have found them useful to understand the spatial impact of loading and support conditions on the structural response. In this regard, outcomes indicate that this collection of interactive problems and exercises is a helpful tool for autonomous learning.

Scalability is one advantage of this repository with interactive exercises and problems, either with increasing complexity or with the number of examples included of which a sample is shown in Figures 4 and 5.

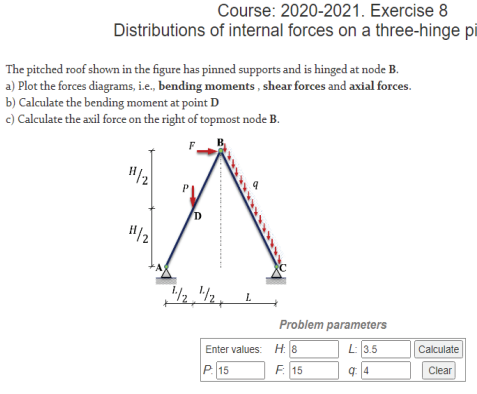

Figure 4. The statement of an interactive exercise on Structural analysis. The user can assign values to diverse parameters. Upon clicking the "Calculate" button, the web system shows the numerical and graphical output, partly shown in Figure 5.

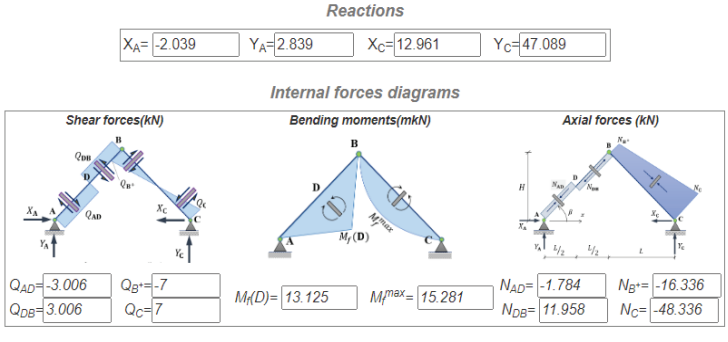

Figure 5. Immediate responses to the interactive exercise on Structural Analysis. When used for self-correction, the user can check his/her own handwritten procedure and results with those from the web.

3. Teaching-Learning Experiences during COVID-19 Lockdown

A summary of the experiences carried out during the lockdown period in engineering modules of the above mentioned three universities is described in this section. Such experiences deal with flipped classroom techniques under the physical constraints of remote teaching and evaluation. The experiences described here correspond to courses

including Strength of materials, Smart construction: BIM, Construction management, Elasticity and Strength of materials II, Operations research I and II, and Dynamic and seismic analysis of structures. These semester modules were taught remotely and engaged 671 registered students.

Some sets of pre-recorded videos with teachings played a core role among the e-resources used in the accomplished flipped-teaching model. Indeed, they constituted a remarkable resource for the autonomous learning stage. Each subject has its own growing collection, which is reviewed on a semester basis. Lecturers prompt students to visualize some videos and do some homework, mainly exercises and problems. To ensure their viewing and comprehension of these multimedia files available for individual study, the pre-recorded videos included short questions sparsely inserted (Edpuzzle) so that students could only continue watching them after replying. Learners highly valued this feature as a motivating feature.

The first class time after the homework study stage was devoted to both testing the at-home individual learning and just-in-time teaching. The former included performing online quizzes through the CRS or responding to an on-the-fly exercise, which resembled the assigned homework, as a way to encourage students in their active learning. The latter helps to promote the use of class time for intensifying active learning [64,72,73]. The underlying purpose of this blended learning approach comprised four ingredients:

- Encouraging open discussion, giving more dynamic classes and lessons more interactively.
- Using technology properly to enhance engagement.
- Keeping, when possible, concise sessions within class time, diversifying activities to avoid boring one or two-hour passive sessions.
- Integrating some type of entertainment and professional perspectives in training.

3.1. Classroom Response Systems

In order to assess their individual learning in the fundamental degree subjects, students were prompted to solve at-home weekly exercises delivered through the LMS and to make short online quizzes with the IRS at least once a week during class time. The digital tools employed were Kahoot, Socrative, and Mentimeter. Figure 6 shows a snapshot of a Socrative item.

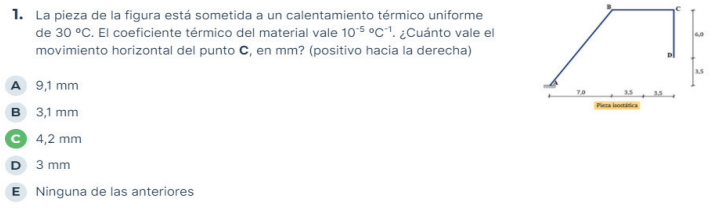

Figure 6. A question from a Socrative quiz on Strength of materials (from the instructor side).

During class time and after closing the online quiz, the lecturer solves the problem or exercise on the tablet and responds to queries or difficulties raised by the students.

Survey results indicate that students highly appreciate the use of IRS in their learning process, as this helps them to make the pedagogical practice more dynamic and point out the relevant issues of a subject.

3.2. Web-Based Parameterized Problems (UJA and UPM)

The use of flipped-learning techniques is starting to be introduced in several courses of Civil and Mechanical Engineering at University of Jaén (UJA). In these courses, mainly dealing with Strength of Materials, it is of paramount importance to help students to master the most relevant aspects regarding the way the beams behave under different loading scenarios, how they modify their bending moment and shear stresses diagrams, as well as

their deformation. These abilities are fundamental for the students to understand more complex structures that are covered in later courses of these degrees.

In this case, the use of web-based problems is focused on flipped-learning experiences where the teacher guides students through a specific problem to make them think and question their knowledge about key aspects regarding the behavior of a beam under loading. The main goal is to stimulate students and deepen their knowledge, so they acquire a certain intuitive understanding of how structures work.

The experience is carried out as follows: at the end of a class, the students are presented a new problem to solve, which has several parameters that can adopt different values (Figure 3 shows one of the proposed problems). This problem can be solved by means of a web page where students can experiment by modifying the values and observing the results in an interactive way (they see the resulting bending moment and shear stresses diagrams, the deflection of point D). The main goal of this problem is not to solve it, which can be easily done with the web page, but thinking of several key issues that the students must try to guess by intuition and, then, check with the help of the web-based problem. To this end, the students are given a set of questions to answer regarding the proposed problem. In the case of the problem shown in Figure 7, for example, they were questioned about how load P affects deflection of point D (does increasing P make D move upward or downward?) and whether load q induces a positive or negative moment in A. Before the next class, the students must use the web page to solve these questions and check if their intuition is correct about them. Finally, at the beginning of the next class, the teacher opens a debate where students talk about their findings. This debate takes no longer than fifteen minutes, but it is extremely rich, since it helps students to connect their knowledge and better understand how structures work. They must be able to solve problems by using specific methods taught in class. They also have the chance to understand them better, often connecting some concepts with others, finding out that what they have learned in different courses are not isolated boxes, but related. The lecturer conducts this debate to help them to find the correct conclusions.

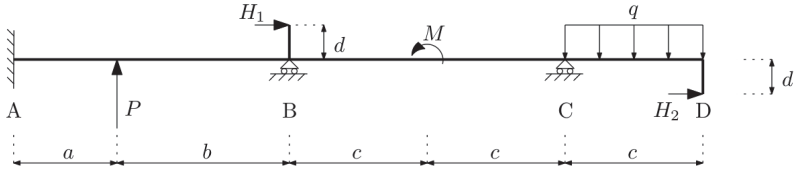

Figure 7. Parameterized problem used in one of the web-based flipped learning experiences proposed at the Universidad de Jaén (UJA).

During these experiences, only about 25% of the students proved to work properly on the problem, the rest only used the web-based problem occasionally but did not think much about the proposed questions. This can be because this was a new experience to them, and they were not used to it. Nevertheless, the experience was interesting for all the students, since all of them were present in the debate, which helped them find the same conclusions as the rest.

The web repository of parameterized exercises and problems also proved to be an adequate resource for guided-study class sessions. The lecturer hands out an online exercise and explains the basic guidelines to solve it. No two data sets are alike, since the statement data (spatial layouts, stiffness, loads, etc.) are functions of the registration number of learners. They attempt to solve each one's exercise and hand it in to the LMS. Then, the lecturer unlocks the URL with the interactive problem so that students can check their corresponding numerical results and find complementary hints. Besides, they can raise queries and arguments, thus converting this part of the class in quality time.

3.3. Web-Based Parameterized Problems (UDEP)

The undergraduate third-year students to whom UDEP allocated the experience featured organizational skills, teamwork ability and responsibility still in the making. Besides, given their work context (social isolation, very large classes, and extensive syllabi), the teachers conducted the research, raised the problems and targets, provided the bibliography and resources, and performed activities to ensure that the students developed the necessary work and achieved the expected knowledge.

The PBL-CRS strategies used in the Operations Research dictation experience encompassed the autonomous study of the theoretical framework and the ex-post resolution of problems assigned to the students, either individually or in teams. The achievement indicators included the application of an algorithm, the ability to introduce a new concept or procedure, to deepen its meaning or usefulness, and/or problem aspects that raised learning difficulties.

With this PBL-CRS strategy, students must argue their answers, thus avoiding random or improvised responses. Unlike the traditional teaching practice consisting of asking questions throughout the session, which involves only a few motivated students, the employed strategy includes a structured questioning process, what requires the participation of the entire class. The autonomous homework stage comprises studying the theoretical background, doing exercises, responding to short quizzes, and designing brief projects. In this regard, they have available the support material and e-resources on the LMS (UDEP Virtual), which constitutes a program of activities that can be carried out either individually or in teams. Thus, they can demonstrate competence achievement for each stage by advancing in the resolution of problematic situations. Figure 8 shows the students' satisfaction survey on the comparison between remotely oriented work and traditional teaching on Operations Research at UDEP.

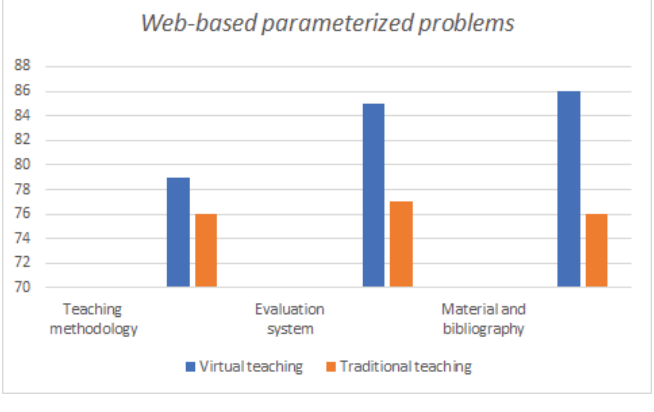

Figure 8. Survey feedback: remotely oriented teamwork with the PBL-CRS strategy versus traditional teaching at UDEP. Ordinates indicate students' degree of satisfaction.

4. Results and Discussion

The web-based resources used for flipped-learning techniques, where the teacher guides the students through some key aspects of the behavior of structures, proved to be of great interest, particularly during the lockdown period. A correctly designed and guided experience by the teacher provides students with a valuable opportunity to think about some general structural aspects that can be eluded by only solving problems using specific methods taught in class [19,25].

The students' participation was somewhat limited, but the final debates that led to highlight the main conclusions took place in front of all the students, so any could follow the most meaningful aspects of the problems.

In this experience, an alternative to traditional engineering teaching has been implemented, developing activities based on the PBL model and adopting a CRS to improve communication in the classroom. The design of the activities took into consideration some learning difficulties and the related teaching proposals and advice identified by the research on the field [34,49–52]. In this regard, noticeable differences resulted in the suitability of web-based methods between undergraduate courses and Master's courses, and between fundamental and technological modules.

Some of the items included in the surveys were:

(1) Degree of satisfaction with the individual learning experience.
(2) Usefulness of such implementation in class time.
(3) Applicability of this procedure to other units in this module.
(4) Fulfilment of learning expectations.
(5) Initial individual readiness to perform the task.
(6) Current readiness after having performed the task.
(7) Readiness to perform the task in groups.

Table 1 shows the results from 220 survey respondents for an undergraduate module taught during the confinement period.

Table 1. Students' perceptions on the use of CRS for assessing learning in a flipped teaching model in Strength of materials at UPM.

Item	Highly Agree	Agree	Neutral	Disagree	Highly Disagree	Mean	Standard Deviation
(1)	20.7%	51.7%	24.1%	16.7%	0%	3.90	0.76
(2)	17.2%	72.4%	6.9%	20.0%	0%	4.03	0.61
(3)	36.7%	26.7%	33.3%	9.1%	0%	3.97	0.91
(4)	26.7%	53.3%	16.7%	12.5%	0%	4.03	0.75
(5)	16.7%	46.7%	33.3%	20.0%	0%	3.77	0.76
(6)	50.0%	36.7%	10.0%	6.7%	0%	4.33	0.79
(7)	71.0%	25.8%	0.0%	4.5%	0%	4.65	0.65

Students were also surveyed about the exams, the usefulness and adequacy of OER. Table 2 shows feedback for technological modules at UPM and UDEP for the following questions:

(1) The ease of last exams: (5) very difficult; (1) very easy.
(2) Adequacy of exams to the subject syllabus.
(3) Preference about onsite exams vs. online.
(4) The usefulness of CRS on your learning achievements.
(5) The usefulness of LMS on your self-paced learning and learning achievements.
(6) How do you value your PBL learning achievement during the pandemic?
(7) Degree of satisfaction with the OER delivered by the instructors of the subject during the lockdown period.
(8) Certainty on having mastered the key concepts taught in the subject.

Table 2. Survey feedback on the adequacy of exams and the usefulness of the OER provided within the flipped teaching model at UPM and UDEP.

Item	Highly Agree	Agree	Neutral	Disagree	Highly Disagree	Mean	Standard Deviation
(1)	0.0%	2.9%	42.9%	45.7%	8.6%	2.40	1.24
(2)	17.1%	54.3%	20.0%	8.6%	0.0%	3.80	1.26
(3)	42.9%	34.3%	8.6%	11.4%	2.9%	4.03	1.51
(4)	5.9%	38.2%	29.4%	14.7%	11.8%	3.12	1.64
(5)	5.9%	47.1%	14.7%	26.5%	5.9%	3.21	1.61
(6)	17.3%	28.8%	34.6%	17.3%	1.9%	3.42	1.57
(7)	36.5%	36.5%	23.1%	3.8%	0.0%	4.06	1.29
(8)	11.5%	36.5%	42.3%	9.6%	0.0%	3.50	1.38

Some achievement indicators are worth mentioning:

- What lessons have been more beneficial in the use of the web-based resources? Around 65% of students witnessed that those interactive exercises associated with the first few chapters ranked at the top because they were helpful to grasp the principles and fundamentals of the module.
- Which are the most complex problems of the repository? Half of survey takers pointed at those of the second half of the course, associated with more advanced concepts.
- Which improvement opportunities are the users demanding? Around 25% of students' suggestions or comments were fair enough to be considered for improving either the content or the structure of the repository.
- Which other lessons or concepts are eligible for inclusion in the repository? Answers ranged from preliminary concepts and theoretical background to advanced topics that belong to subsequent modules.
- The ease and usability of the web-based tools: the mean value was 3.65 in a scale from one up to five.
- Other comments: 48% of surveyed students stated that they lacked the fundamentals needed to properly achieve the subject skills and learning.
- The dropout rate in fundamental subjects reached 22%, which was notably higher than in technological modules, which was lower than 10%.

Feedback from surveys, outcomes, and interviews indicate that the use of CRS promoted a mind shift in students: more than 50% have increased attendance and improved their achievements. More than 35% swapped shyness for active participation in the classroom, along with transferable skills. In exchange, they demand some reward for accomplishing these tasks. On the lecturer side, CRS become helpful instruments provided that they may make the classroom pedagogical practice more dynamic. Besides, CRS tasks yield a rapid assessment, which can become motivating for students and useful and low-effort demanding for teachers [74–77].

Two major forces have affected higher education during the lockdown period caused by the global sanitary crisis: digital technology for remote teaching and the policies and structures of higher educational entities. The former issues have increased the access, inclusion, and efficiency of some processes, albeit the outcomes seem to highly depend on its implementation [28] and monitoring [67]. Another remarkable benefit is that, when combined with some blended learning models, students can take ownership of their active learning [78–80]. Indeed, more than a few universities are boosting vice-rectorates of Strategy and Digital transformation. This passes through the modernization of equipment, facilities and digital media, but it must involve a widespread set of measures to tackle three pending tasks: the digital divide, inclusion, and the quality standards. The former entails that lecturers acquire digital competences accordingly [81]. The term inclusion refers to the

ongoing, and transformative, process of improving education systems to meet all learners' needs, especially focusing on low-achieving students or students from low-income families.

Likewise, there is wide concern that universities are lowering the bar and dropping the standards, so student training is becoming poorer. Module requirements have lessened and the implicitly assumed levels of reading and writing are cutting off [82,83]. This entails that the students devote less and less time to their studies and fail to develop productive skills such as critical thinking, spatial reasoning, or argument abilities, among others [84]. As a result, some grade inflation seems to have appeared [85–88]. Many classes are still designed as passive lectures with few applications and scarce active engagement, which limits skill development and competence acquisition [89–91]. Conversely, achievement is directly linked to the stimulation of meaningful learning by delivering information in a clear and alluring way, relating it to the learners, and using conceptually demanding learning tasks [92]. This, indeed, involves the use of digital technology. In this regard, the authors witness that web-based, learning-aid resources can be valuable tools for engagement and active learning.

Research on flipped learning, understood in terms of peer-reviewed journal articles, books, and conference proceedings, is soaring from these last years on. A variety of experiences and studies can be found elsewhere with regard to the switch to online teaching and examinations because of the pandemic. Online higher education has taken a step forward, and, somehow, most lecturers are increasingly teaching online on a regular basis [50,52,56]. Instructors and administrators realized that physical attendance to classes is not linked to learning outcomes [46,48].

Some studies reflect students' dissatisfaction with online learning in general during the lockdown period, and particularly with the communication and Q&A in online classes whereas the combination of online teaching with flipped learning model has improved students' learning, attention, and evaluation of modules [44,48]. Conversely, this study has not detected such degree of dissatisfaction among students in view of the results [26,43,54]. The teaching experience acquired from the pandemic sheds light about strategies and practices to be kept after COVID times, since they are suitable to switch between blended and online classroom models [26,46,52]. Other studies show a high agreement among students that flipped teaching has promoted the development of valuable skills for their personal and professional future. These include character building, collaboration, communication, citizenship, critical thinking, leadership abilities, digital competences, and creativity [50,53].

The higher education landscape has abruptly changed as a consequence of the 2020 pandemic. Since then, students are intensifying their daily activities with technology. They have assimilated, more deeply than instructors, the key role of technology in academic life. Back to classrooms, the authors have verified the bigger presence of diversity of digital devices in face-to-face sessions, which call learners' attention even more than the blackboard or the screen. Furthermore, attendance has lessened, not strictly attributable to sanitary issues. Even more, students from a large set of universities are claiming for pre-recorded classes and online exams, rather than for remote online teaching. Thus, the authors state that Internet-based tools are becoming increasingly necessary to communicate with students and to achieve more intense student follow-up: Learning Management Systems, online meeting software, e-textbooks, immediate response systems, blogs, multimedia content and repositories of web-based interactive tools, among others. These mixed tools should be designed for multipurpose activities, either face-to-face, remote, or blended, including autonomous learning.

Lastly, one remark about eventual online exams: as students are currently displaying preference and claiming for sitting online exams, it becomes mandatory for higher education authorities to issue policies and measures to tackle the difficulty of ensuring the fair assessment of learning.

5. Conclusions

The recent lockdown period has emerged as a chance to value the efficacy of teaching modes. The flipped teaching methods implemented by the authors during this sudden shift to remote teaching have suffered less than other classical teaching approaches, not only with regard to lectures but also to the outcomes. Lecturers struggled to take advantage of the best of the former to adapt them to a virtual context.

The procedure presented here is a suitable strategy to find a trade-off between using digital technology in engineering courses and keeping the rhythm, the quality time of classes, communicating with students and teaching staff, as well as ensuring meaningful learning. Some of the strategies and practices implemented during the lockdown period have entailed such a positive impact on the teaching practice that they have arrived to stay for the future: the tablet as a teaching instrument, pre-recorded videos with queries-to-go, repositories with questions for on-the-fly quizzes, the ability to hold online meetings among teaching unit members, among others.

Hence, an increasing concern on how to address the pervasive use of technology to achieve the effectiveness of the training system has emerged. There is a wide range for action, not only in technology but also from an ethical and holistic perspective.

The authors agree that physical attendance to classes is not linked to learning outcomes. The slight differences in passing students percentages with respect to the ordinary face-to-face teaching, their feedback on satisfaction, figures of learning outcomes, and the given step forward to digitalization in higher education can be highlighted as benefits of the actions undertaken by stakeholders. Conversely, the experience from the lockdown physical constraints has raised some controversial aspects that require further research:

- Students and lecturers' readiness to adapt to the digital transformation of higher education.
- The confidence in technology and the efficient use of digital devices to promote active learning and effective training settings.
- Digital technology has influenced students' attitude, readiness, and treatment with instructors. It seems worth investigating the moments and ways students communicate among them and with lecturers during the course.
- Assessment of whether higher education is lowering the standards or not.
- How to design appropriate remote evaluation procedures to measure goal achievements while ensuring honesty, ethics, and fairness.

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Instructional Planning Modifications to Meet Social Distancing Requirements: Secondary and Post-Secondary Options

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Abstract: Secondary and post-secondary science and engineering educators share common class arrangements with both a laboratory and lecture component, coordinating both components so they build upon each other to create meaningful learning experiences. The COVID-19 pandemic forced educators to convert lectures and exams to online delivery. Doing so came with trade-off decisions about sacrificing laboratory experience goals of hands-on practice, problem-solving, and learning concepts at a deeper, tactile level. Due to rapidly changing conditions, educators faced course redesign to accommodate social distancing and virtual learning requirements. In this study, a team of undergraduate college students including one secondary science preservice teacher planned a set of lessons for STEM outreach to a K–12 audience. The team faced challenges in planning meaningful learning experiences in the face of COVID-19 uncertainty. Options for secondary and post-secondary educators to consider are provided in this article.

Keywords: COVID-19 instructional response; instructional planning; preservice teachers; STEM integration; in-service teachers; undergraduate research; flexible teaching

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1. Introduction

Science and engineering educators at both secondary and post-secondary level share a common class setup as one having both a laboratory and lecture component [1]. Educators must coordinate the components of a course (lecture, discussion, laboratory experience, homework, projects, and exams) so that they build upon each other to create a holistic experience that works for all students and fits the confines dictated by term length, school breaks, and standardized testing [1,2]. The COVID-19 pandemic caused unprecedented challenges in science and engineering instruction. Educators were forced to react quickly, converting lectures and exams to a remote format, and perhaps cutting out lab components altogether. This was necessary as physical facilities closed, but it often came at the price of not meeting long-established laboratory experience goals of hands-on practice, problem-solving, and learning content at a deeper, more tactile level [3].

By the summer of 2020, many educators found themselves in a perplexing situation: there was time to plan for the fall term, but the social-distancing conditions of that term were still widely unknown. How, then does an educator open this lock, to plan for adaptations and redesign contingent on developing local conditions and likely to change at any time with little warning? The key is that educators must prioritize delivery methods according to purposefully chosen learning objectives in line with preferred instructional strategies.

The authors of this study wished to explore and describe the process of planning instruction under the unusual circumstances of the global COVID-19 pandemic. How does a (preservice or in-service) K–12 science and/or engineering educator prepare lessons

for a broad spectrum of delivery modes? Did educators explore the trade-offs of each given the lesson goal? Although researchers have reported on teaching and learning experiences [4] and institutional responses at the onset of the pandemic [5], there is a lack of understanding about how teachers began to plan for instruction as the pandemic continued. The authors seek understanding of how teacher educators would approach the instructional planning process. This study tracked one team, consisting of undergraduate college students including one preservice science teacher, who participated in a grant-funded project Learning to Integrate Fundamentals through Teaching (LIFT). The purpose of this study was to describe how the team responded to the challenge of planning for a series of outreach-style minilessons to deliver to a K–12 student audience.

1.1. Traditional Instructional Planning Process

The process of planning for instruction historically has been careful, thoughtful proactive decisions and actions meant to effect permanent, meaningful changes in student outcomes. A typical, pre-pandemic instructional planning process often began with a set of learning goals, and one task was to determine how to meet learning goals using appropriate technology and delivery methods [6]. A typical integration of instructional technology may have been to adapt and add online or digital components to a traditional face-to-face course, thereby changing delivery to include technology [7]. Selection of course components to adapt was made according to the delivery mode and technology that may best accomplish learning objectives targeted toward meeting learner needs [8]. Course planners had options of mixed/hybrid delivery that includes components of in-person and virtual activities implemented together, enhanced in-person courses with some online components, or asynchronous online courses, which included activities meant to establish a learning community, such as threaded discussion boards [9]. Planning may have included conducting what instructional designers term a *needs analysis*, in which information about prior knowledge, motivation, interest, and engagement of students is collected and analyzed, formally or informally [7,8,10]. Prior to the pandemic, asynchronous, fully online course delivery modes typically were designed under the assumption students would not be able to meet synchronously or in-person. Other delivery modes accommodated students and educators meeting in-person informally or formally, student-initiated study groups, student-teacher conferences and feedback sessions, and presentations delivered synchronously.

The educator's task was (and still is) to plan the instruction, focusing on pedagogical content knowledge, instructional strategies, and assessment. The instructional planning process encompasses:

- Decision of course delivery mode (e.g., online, in-person)
- Decision of instructional technology integration (pedagogical technology such as Zoom, learning management system, etc.)
- Decision of content (e.g., applying pedagogical content knowledge, incorporating content and learning activities, assessment of learning, etc.).

During the planning process, educators may focus on constructivist learning through authentic learning activities, cooperative and collaborative learning, learner–learner interaction in pairs or groups, and synchronous or asynchronous class meetings [11]. This attention to learning spaces considers the learning goals and the needs of students to interact and learn socially. The process is iterative under the assumption that changes to future course offerings may be made according to student learning outcomes, course evaluations, and/or educator reflective practice rather than a reaction to outside events.

The process of integrating technology is thoughtful, reflective, and time consuming. One researcher estimates up to nine months to fully redesign a course, including quality control checks [12]. To provide an example to illustrate the rationale for the lengthy planning time, some researchers [9] suggest six aspects of synchronous technology to consider before choosing to integrate technology such as web conferencing, including facial expressions, voice nuances, visual and verbal feedback, collaboration, support from the instructor and class, and socialization. A clear option is to blend or incorporate

other technologies to incorporate all the desired aspects of an in-person class and fulfill student learning needs in an efficient, cost-effective manner [9]. Many secondary and post-secondary educators welcome the feedback and support from course designers in navigating this decision process.

Unfortunately, the unexpected and severe onset of the pandemic disrupted the typically thoughtful and sometimes lengthy planning process and added complexity. Entire institutions and every course needed to quickly transition to remote, online learning, regardless of the educator's prior experience and comfort level teaching with technology. In many cases, the educator faced a steep learning curve with technology and course delivery options. As a result of the sudden and significant changes to all courses during the onset of the pandemic, many educators were left without feedback and support as they adapted courses in response to an outside, unprecedented world event. Moreover, the typically lengthy course redesign process was abbreviated. The standard instructional planning process may have been of limited use during the COVID-19 pandemic because of a variety of reasons including (a) the short time frame—all courses needed to be redesigned practically overnight; (b) the uncertainty of whether the redesign was temporary and how temporary (i.e., rapidly changing conditions); (c) all courses had to be delivered virtually and remotely without any accommodation for in-person activities due to social distancing; and/or (d) all courses regardless of program requirements needed to have the same delivery format, often using the learning management system and/or web conferencing software that the institution recommended or mandated.

A common course delivery mode adopted during the COVID-19 pandemic included synchronous online use web conferencing technology (e.g., Zoom). A synchronous online course may benefit from interactivity and participation from all students [13]. Researchers recommend providing opportunities to communicate with others and build a learning community [14,15]. In addition, researchers have shown prerecorded delivery content such as podcasts to be effective in delivering resources in the field and in the laboratory [16,17]. However, educators may need to scaffold the process of building an online learning community, model good participation, manage online discussions to set limits, yet generate and maintain interest, and promote a welcoming, inclusive atmosphere [13]. These aspects of online learning spaces may be unfamiliar to educators and must be internalized and practiced by them in addition to teaching course content.

1.2. Informal Instruction and Planning

Because the LIFT project incorporated both traditional teaching aspects (such as lesson planning) and informal aspects (such as connected lessons separated over large time spans), a brief review of informal practices is in order. There are multiple studies that showcase aspects of informal instruction such as the use of virtual spaces [18], teacher leaders [19], creativity [20], impacts on pre-collegiate teachers [21], novice teachers [22], university collaborative approaches [23], and many others. One particularly interesting study [24], which predates the pandemic, called for clarity surrounding *formal* and *informal* learning. The authors stated (p. 130), "We argue that in order to fuse informal and formal learning, mLearning designers need to offer more clear definitions of the concepts 'formal' and 'informal'; they need to omit some design aspects to the learners themselves, or to offer a design in form of a learning path that students themselves can customize according to their learning habits, routines, and preferences."

Although the article by [24] focuses on mobile learning, the lessons are applicable to a variety of delivery modes. [24] speak to the study that is described here in that they call on three distinctive characteristics of mobile learning (authenticity, collaboration, and personalization) along with sub-categories of situatedness, contextualization, conversation, data sharing, customization, and agency. These aspects were considered in the LIFT project, although some of them were implicitly considered. As [24] pointed out, aspects relating to informal learning are positive. They offered several implications for sustainable mobile

learning including clear definitions and explanations of concepts, learner control of relevant design aspects, and learner customization of a path of habits, routines, and preferences.

The authors of this study in the LIFT project realized although informal spaces are perceived as positive there are still multiple aspects of informal spaces that necessitate more formal and traditional planning and implementing. The authors did expect and communicate to the LIFT team that they define what they wanted to teach (including what, why, and how), control the options for pre-collegiate students to learn, and create routines for the team that could be replicated with the pre-collegiate students.

1.3. Setting and Context of Study

The LIFT grant-funded project formed undergraduate interdisciplinary teams from science, technology, engineering, and mathematics (STEM) as well as education. The team selected a topic of interest to research, design, and build a data collection device (payload) that integrated all disciplines of STEM (also called integrated STEM) to gather data answering a scientific question or solving an engineering problem related to the topic of interest. The main element of LIFT is that the question or problem is answered by collecting data on sensors attached to a high-altitude balloon. Undergraduates attach the payload to a high-altitude balloon, analyze the results, and communicate findings. Although balloon projects have been used for scientific research and projects have included secondary and postsecondary students for years [25–28], the pre-determined projects often collect data related to temperature and other atmospheric characteristics [29,30]. The LIFT project differs with undergraduate participants choosing ill-defined questions and problems with is consistent with authentic science practices [31]. The undergraduates that form these interdisciplinary teams design and teach lessons and activities as STEM outreach to K–12 students.

In this project, a team of three undergraduates (physics, education, and computer engineering majors) worked with secondary students in eighth grade (typically 13–14 years old) to design an experiment in radio occultation that gathered data on sensors attached to a high-altitude balloon. During the spring semester of 2020, the team designed and planned a set of lessons and activities, aligned with state science standards, which encouraged eighth grade students to join the team in hands-on, scientific inquiry. The following semester, the team planned to implement the lessons and activities with eighth grade students, include them by launching the high-altitude balloon from the school grounds, and analyze and interpret the results that they and the eighth grade students retrieved. However, as summer 2020 progressed, the team faced uncertainty about fall 2020 visits to the classroom.

In this study, the focus was on one minilesson delivered in an outreach format to an eighth grade (at a public middle school with students aged 10 to 14 years) science class, and how three undergraduates developed that lesson with the added challenge of planning how to implement that lesson under a variety of scenarios determined by the COVID-19 pandemic constraints. While there is literature surrounding how to effectively develop online course structures, they often presume sufficient time for creation [32], and rarely focus on preservice and student teachers [33]. This research study fills a gap in the literature about rapid planning and course changes to online formats, rather than instructional planning with time for careful attention to organization of materials, by novice teachers. The authors of this study pursued the following research question:

Research Question: How does an interdisciplinary undergraduate grant team, including a late-term preservice K–12 teacher, prepare science outreach lessons for a broad spectrum of potential delivery modes?

2. Materials and Methods

This study was a qualitative case study that took place at a research university in the United States (U.S.). The purpose of this study was to describe both the process (planning) and product (implementation) of the minilesson for STEM outreach to eighth grade students at a public middle school in the U.S. The authors of this study functioned

as researchers in a detached participant role. The theoretical perspective was interpretivist and focused on description [34]. The nature of the case study was instrumental by studying undergraduates to interpret how educators reacted to the planning challenges caused by the pandemic [35]. The case was bounded by one university in the U.S., with a team of three undergraduate students including one preservice secondary science teacher planning and implementing a minilesson to a group of K–12 students.

The participants in this study were a team of three undergraduate college students: a physics major (female), a computer engineering major (male), and a preservice secondary physics teacher education major (male). The project also aimed to foster integrated STEM learning by interdisciplinary work to prepare these undergraduates for their future career [36,37]. The undergraduate college student participants consented to participate in this study, which was approved by IRB. The eighth grade students they worked with, as well as the partner teacher and school setting, were not included in the study. The team developed and taught outreach lessons to students using hands-on, authentic scientific inquiry, through a radio occultation experiment with lessons aligned to national physical science standards [31,38]. The created lessons provided background knowledge about meteorology, GPS technology, and weather prediction by radio occultation, a method by which satellite signal diffraction is analyzed to give information about the atmosphere through which it passes. The team followed the balloon launch experiment by discussing results with students.

The team translated the radio occultation project into lessons and activities appropriate for eighth grade students to engage in STEM data collection, witness the launch, help analyze the results, and participate in sense-making. They aligned the topic with physics concepts in physical science national and state standards [38]. The partner eighth grade in-service teacher at the middle school scheduled three class periods of instruction for the undergraduate team to conduct the outreach activity. The team planned the first time-period to provide background knowledge about meteorology. The lessons fostered an understanding of GPS technology. The second time-period lesson established foundational knowledge for the subject of the experiment: weather prediction through radio occultation. This is the method by which a satellite signal's refraction is analyzed to give information about the atmosphere through which it passes, thereby supplying data for weather forecasting. The launch of the balloon itself was an additional activity not counted as a class time-period. After the balloon launch, the team planned the third and final time-period to share results and discuss with K–12 students how to analyze and make sense of the results as well as what improvements and next steps in research might be.

Data includes field notes and observations of the process of planning, reflections of the participants about the planning process, and observations of the implementation of the lessons. Lesson plans and outlines of scenarios are the products of this study along with participant reflections as noted in final interviews. Table 1 shows the *original* outreach teaching plan according to topic and class periods.

Once satisfied with the plans, the team considered how the outreach activities would fit into school reopening scenarios. Many public schools did not solidify school reopening plans until August 2020. Therefore, the design process was somewhat speculative, outlining many paths given a continuum of possible classroom scenarios. Table 2 showcases how the team adapted lessons for several social distancing scenarios.

The first scenario presented a normal class time-period with the entire class present and teaching in-person. The team faced a unique second scenario due to school policies regarding visitors; they prepared for this scenario by sending lesson and activity plans to the partner teacher to facilitate while they participated virtually. The third scenario of in-person meeting called for half the class to attend school on alternating days for reduced capacity. Remote synchronous is set up like in-person but takes place at home; everyone logs onto a program such as Zoom at the same time to hold a verbal discussion. A remote asynchronous scenario is one in which all lessons and instructions are prerecorded so students view lessons and contribute to a written discussion thread with a time lag.

Table 1. Central Topic and Arrangement into Modules.

Learning Activity	Topic 1: Weather	Topic 2: GPS/Occultation	Topic 3: Launch and Follow Up
Content Delivery: guiding question, topics	-weather prediction -weather balloons	-How can you describe a point in space? -distance from 3 other points -sound occultation demo	-Why are high-altitude balloons useful?
Experiments	-hot/cold water currents -forming a cloud in a bottle demo/activity -fill a balloon by heating demo/activity	-Triangulation using 3 strings represents GPS, end of string represents satellite, length of string represents time. -phasing out a sound wave (physics toolbox app) -light wave through different mediums	-launch of high-altitude balloon to measure GPS occultation
Discussion/sense making	-3 factors in weather prediction: temperature; pressure; humidity. -Other items: data resolution; high altitude measurements; lots of measurements	-radio occultation as a forecasting tool -air density cause phase shift -temperature, humidity, pressure can be derived	-data analysis -limits of occultation -benefits of occultation -future experiments or other applications

Table 2. Social Distancing—Possible Adaptations.

Social Distance Conditions	Content Delivery	Experiments (Labs)	Experiments: Launch Itself	Discussion/Sense Making
3 days in classroom, everyone present	In-person delivery-mix of lecture, review, data analysis, and prerecorded, narrated videos	In-person delivery with students in small groups; demo to whole class	Launch: In-person delivery with students standing at a distance from balloon as it inflates (typical procedure)	In-person discussion and analysis with whole class or small groups
All students in classroom, remote LIFT team	Teacher plans for lecture, analysis, prerecorded videos	Teacher plans for facilitation of students in small groups; prerecorded demo	Launch: In-person with limited balloon launch witnesses; smaller group stands further back	Students in-person, facilitators participate via Google Meet, teacher displays Google Meet session and participates
$\frac{1}{2}$ capacity classroom, $\frac{1}{2}$ remote, alternating days	Prerecorded videos	Repeat in-person small group experiments with both student sets	Augmented reality launch; one group witnesses in-person; the other group watches launch video	Repeat in-person small group discussions and data analysis twice
Remote, synchronous via Google Meet	Google Meet conversations, prerecorded videos	At-home experiment with Zoom instructions and office hours	Augmented reality/remote launch via live stream: students follow along remotely	Google Meet discussion
Remote, asynchronous	Prerecorded videos	At-home experiment with prerecorded podcast instructions	Remote launch (not necessarily at school site); students follow along live or watch later	Prerecorded video; asynchronous discussion forum

Data analysis consisted of triangulation of products, process planning, and observations of multiple meetings and planning sessions. Data to be analyzed included the participant-generated scenario chart, field note observations of meetings throughout the project, field note observations during the implementation of the lessons, and final in-

terviews with participants after the completion of the project. The authors discussed interpretations of meetings and lesson implementation, ultimately reaching a consensus.

3. Results

The task of planning for different reopening scenarios compelled the team to prioritize some instructional components and eliminate others. They prioritized moving content instruction (lectures) to remote delivery online. As undergraduate students who have taken online classes, including after the university pivoted to completely remote in Spring 2020 in response to the COVID-19 pandemic, they have used tools to convey information online, such as videos which combined lecture footage with digital graphics. The transition may even be considered an improvement; the team found they could edit and perfect content before posting and students could repeat and pause as often as desired. They made plans to integrate instructional technology such as podcasts, which researchers have shown effective in delivering resources in the field and in the laboratory [16,17], but ultimately settled on prerecorded videos that students could watch by following links. They did not expect these formats to pose a challenge to eighth grade students whose curriculum were also affected by the pandemic and therefore have similar previous experience.

Based on the preservice teacher's education and experience, the team decided that a crucial use of instructional time was sense-making through discussion-based learning [15,18]. They felt it was important to include interactive discussion and sense-making conversations in every delivery scenario as researchers recommend providing opportunities to communicate with others and build a learning community [14,15]. In planning for asynchronous instruction, they chose online discussion boards to monitor learning.

Experiments (labs) presented a complicated problem to solve. Given the middle-school audience and the learning goals, the team decided that with minor adjustment, experiments could be completed from home if adequate instruction were given. They recognized the challenge, teaching remotely, of how to effectively guide experiments middle school students complete at home. The experiments must be safe, relatively inexpensive, and reasonably clean. Instructions need to be clear, especially if delivered asynchronously. This brings a disadvantage, however, in that students cannot ask questions and get immediate feedback. Some students may be quite disadvantaged with an at-home lab scenario in terms of equity and access issues, and although the issue remains deeply concerning, it goes beyond the scope of this paper. The team thus planned for all school delivery options.

The team considered additional lab options appropriate for social distancing requirements. The actual balloon launch to collect data showcases how an actual experiment (lab) could be altered to fit the continuum from in-person to remote. In the past, launches had taken place in an open area near the school. Students walked out to witness undergraduates fill the balloon with helium, attach the payload, and release the balloon. Sometimes students board a bus and accompany the university group to retrieve the payload after the balloon bursts and returns to the ground. Adaptations for social distancing regarding the launch began with an in-person scenario. The balloon, as it inflates, poses a slight safety risk of hitting someone if it wobbles in the wind. Therefore, even in normal times students are asked not to approach the balloon too closely. Stricter social distancing requirements called for augmented reality and remote access. Fortunately, two augmented reality applications accompany the balloon payload: a satellite communication device (SatCom) and a set of HD cameras. The SatCom transmits real-time GPS information (latitude, longitude, and altitude) and atmospheric data (temperature, air pressure, humidity, and wind speed) directly to the internet. Using a unique webpage with a real-time mapping interface, interested onlookers could follow the balloon flight virtually [39]. This provided a way to accommodate fewer students witnessing the launch and the possibility that students would not be able to accompany the team to retrieve the payload. Students, from home or from school, were able to view the balloon's path on a map, monitor real-time atmospheric conditions, see where the balloon burst, and locate where the payload landed. Later, after the team retrieved the payload and process the onboard HD video footage, students could

watch a replay of the balloon's actual journey into the stratosphere [40]. These augmented reality applications afforded the actual balloon launch to still be possible even under the most restricted scenario, in which the team would need to launch the balloon at the university and middle school students must follow along remotely from home. Other examples of online science access can be found in remote telescope observations [41], PhET [42], and others [43].

There are some additional affordances, unique to the LIFT project in this study, that offer students a chance to move into virtual reality. Part of the payload may move data into Google Earth by sending along a *Septentrio* GPS receiver. It includes data to create a KML file that can be imported to Google Earth. This allows students to see a 3D model on Google Earth of where the balloon went, including allowing side viewing. The *Septentrio* records highly accurate location and altitude data every second, so it theoretically should transpose a little line of the balloon journey over a model of Earth.

3.1. Actual Teaching Scenario

The school where the eighth grade class participated resumed school in fall 2020 under a socially distant scenario. Half of the student body attended two days a week, while the other half attended on the other two days, with Fridays reserved for offering extra assistance. The principal of the participating school initially did not allow visitors into the school during fall 2020. The team therefore chose to offer the lessons in a synchronous remote delivery mode. The partner teacher cooperated with the undergraduate team by communicating via email about the lesson plan, helping to set up the demonstrations, supplying materials and logistics of the learning activities, and training the team on the use of Google Meet, the synchronous delivery platform the school used. Table 3 displays the actual social distancing restrictions the team taught under. Note that the actual scenario closely but not exactly fits one of the possible adaptations described in Table 2.

Table 3. Actual classroom conditions for lessons.

Social Distance Conditions	Content Delivery	Experiments (Labs)	Experiments: Launch Itself	Discussion/Sense Making
$\frac{1}{2}$ capacity classroom, $\frac{1}{2}$ remote, alternating days, remote [blinded] team	Partner teacher plans for lecture; delivers prerecorded videos from team; repeated lesson twice	Partner teacher plans for facilitation of students; delivers prerecorded demo from team; repeated lesson twice	Launch: Everyone in-person with social distancing guidelines (held on Friday when all students attend school)	Students in-person, partner teacher delivers prerecorded video from team; repeated lesson twice
[blinded] team: Remote, synchronous online	Synchronous online discussion, prerecorded videos	Synchronous online discussion		Prerecorded video

As planned, the team met remotely with students synchronously online (Google Meet) twice a week to deliver the minilesson to all students (half the students in each alternating day). The lessons proceeded by the undergraduate team logging into Google Meet synchronously but sometimes separately due to quarantine, isolation, etc., at the appointed class period time. The team introduced themselves and turned on their camera and audio. The eighth grade students in the classroom appeared to watch on a large projection screen and be able to hear. When students had a question, they approached the partner teacher's laptop to ensure the undergraduate team could hear them through the laptop microphone. The undergraduate team also prepared videos in which each team member explained scientific or engineering concepts, which were played by the partner teacher using a link. These prerecorded videos appeared to ease the technological challenge of varying bandwidth and static of transmission, and students appeared able to see and hear. The partner teacher conducted demonstrations in the eighth grade classroom. In the case of the GPS/string activity, students participated and moved around the room while the undergraduate team viewed the activity from the laptop vantage point, which

did not always show the full picture. When the undergraduate team was able to gather, they scheduled time in an unused classroom at the university and turned on the instructor station webcam and microphone. Members of the team used the university classroom whiteboard to explain concepts and focused the cameras on their payload to allow the eighth grade students to observe.

An unexpected development happened with the school principal for the high-altitude balloon launch. The principal allowed the launch to take place on school grounds in a large open field and allowed students to walk out and view the launch, provided social distancing measures were in place. The launch was scheduled for a Friday, a day in which all the students were attending, eliminating the need to launch the balloon live for one half while the other half watched from home. The undergraduate team asked a few eighth grade students to assist with holding the payload and other tasks. The team, especially the secondary science preservice teacher, talked with the eighth grade students and establish a learning relationship, which heretofore had been only through video, by re-introducing himself and asking students questions designed to trigger previous learning and make connections between the minilessons and the actual launch.

3.2. Reflections on Actual Teaching Scenario

Table 4 displays quoted reflections from each member of the undergraduate team regarding how they thought the actual teaching scenario compared with their original plans. Every team member mentioned the unexpected, uncertain nature of the COVID-19 pandemic affecting their uncertainty about delivering the lessons and even launching the balloon. Every team member expressed satisfaction with how the lesson and launch ultimately turned out. All names are pseudonyms.

Table 4. Reflections by Undergraduate Team on Actual Teaching Scenario.

Undergraduate Team Member	Met Original Goal?	Challenges?	Successes?
Gail (physics major, female)	Even despite the pandemic . . . I don't think it shifted our goal too much from what we originally had planned.	I had wanted to, you know, go in and actually interact with the kids and get them interested in science, but we weren't exactly able to.	. . . but I think despite all that, it still went over well. The project did, and the impact on the students too, from what I can tell.
Glen (computer engineering major, male)	[Teaching remotely] did make it a lot harder. [In-person] they could [have gone] up and look at [payload] and actually see where the parts were, what they looked like, what they did, and we could have, like, talked to them while they were looking at it. And kind of have them look around the box. Because it's not really fragile, so they can kind of turn it over and stuff . . . I feel like [remote lessons] did make it a little bit harder for the students.	I think the prerecorded video was a lot easier for us. But the bonus of the in-person is that we kind of had to prepare for it, and then we were also able to see like the reactions and get questions and help the students a lot more. So, and like in the recorded videos, you can't really do that. You kind of just say stuff and then if you think it will help the students but really it doesn't, you don't know. We did have a big lack of questions with the remote [lesson delivery], which I guess is another con of going online and doing it remotely, is you can't really force students necessarily to ask questions, so there's that.	When we had to simplify some of the radio occultation, what it was, like when you simplify it, it kind of makes it easier for you to understand while you're teaching it . . . So like when you're trying to teach it, you can kind of put together how to make it simple, and then it kind of teaches you the overall concept of it better, I think.
Gabe (secondary science education major, male)	I feel like uh, for the first lesson, I think that was probably our weaker of the two lessons. I think we were relying a bit too much on the premade videos. I mean, we had to try it out, right? I mean, I don't regret trying it out. But I think in the end that wasn't as effective as the synchronous communication.	Well, uh, we didn't really know what was going on. Um, for most of [the synchronous lesson]. And I feel like because of that, the timing was pretty messed up in some places. Some classes we had like 10 min and I just kind of filled in the time, and some we had, like a minute at the end to try to squeeze all the information into.	Teaching experience is always good. It was a novel experience too; I had never before taught very much over remote methods. And I had never really spent quite as much time planning out demonstrations. That was the fun part of it.

During interviews and other data collection, each undergraduate participant commented on a different facet of the experience. Gail, the physics major, emphasized how the team persisted with their original learning goal and met success despite setbacks of remote delivery. Glen, the engineering major, examined the trade-offs and analyzed how the hybrid in-person/remote delivery method resulted in learning deficiencies as well as advantages. Gabe, the education major, appreciated the opportunity to try a delivery method that he perceived as new, but lamented the constraints of planning for a single outreach educational experience without opportunity to engage in reflective practice to optimize the lesson. The impacts of the pandemic appeared to recede and be supplanted by the nature of single-encounter outreach lessons preventing careful planning, which includes both iteration and optimization. For future teams or groups, the authors recommend lesson planning with a focus on possible iterations and optimizations.

4. Discussion and Conclusions

Overall, the *take-away* message from this study is that instructional planning should be intentionally deliberate and takes time for option processing. The pandemic forced planning to become reactive, quick, and subject to change, and this shift removed intentional planning time from many early scenarios. What the LIFT team did was take a *slow-down* proactive approach to plan for multiple scenarios in the upcoming lessons, and that allowed the team a bit more flexibility in the teaching moment. After the lessons, the LIFT team also indicated that they wanted to improve the lesson, either by delivery method or teaching strategy that they thought might have been more effective than what was utilized when teaching. A proactive approach of planning scenarios and then reflecting on teaching effectiveness does not solve the problem of creating all possible teaching options, but it might lessen stress during the moments of teaching. Sharing these optional lesson aspects could be crucial if another pandemic or unexpected event causes another abrupt shift in teaching planning time.

If one contrasts the pandemic response redesign with a traditional course design process, the main difference is that in traditional course design, the course is designed or redesigned for online delivery and activities are designed in advance of the start of the course. In a rapid reformatting scenario, the opposite happens. Activities are not planned until the instructor determines what delivery mode the course needs to transform into, and the delivery mode may change during the course or in the moment, perhaps just before, during, or nearing the end of the activity. Historically, course design has not veered off unexpectedly into a different delivery mode, nor is an online/remote course traditionally defined as a course that switches back and forth depending on health concerns, nor one in which students move in and out of remote and in-person attendance due to quarantine, isolation, etc. The mass uncertainty and unprecedented nature of the pandemic is to blame for an uneven and tentative course design response by institutions of learning. Specifically, with prompting, the LIFT undergraduate team planned for the unexpected remarkably well considering their lack of teaching experience. They kept the original goal in mind as circumstances continued to change. This model can be replicated, and the authors argue should be replicated, and thus was the impetus for this article.

The first author of this study draws from personal experience of planning and teaching a college-level course during fall 2020. She found herself planning for activities to take place in person, but a few weeks later, the institution pivoted to an online start with a transition to in-person learning after eight weeks. In response to rising numbers of COVID-19 cases, instruction was *paused* for a week in which no one was allowed on campus. The semester ended with a return to online delivery a week earlier than expected. Despite her prior experience with both teaching and instructional design, she felt frustrated and ultimately canceled some learning activities, because in the moment there was not time to change delivery modes so rapidly. In retrospect, she feels that there was a benefit from planning the next course according to possible delivery scenarios, like the LIFT participants in this study did, and it reduced her stress.

A positive aspect of the COVID-19 pandemic is attention to renewed intentionality in planning and how instructional time should be used. If course designers are unable to assist in a lengthy redesign process, educators then must also concentrate on the structure and planning of the course beyond content and student engagement with the content. Multiple repetitions of redesign options transform into further iterations as educators react to what did not work well the previous semester, and this provides more options to choose from as courses come and go. Publications such as [9] may provide concise guidelines, but repositories of the same lessons taught in multiple formats would be beneficial for educational instructors. For example, if course delivery must change to synchronous online (e.g., Zoom) sessions, educators may have to consider how to model interaction by requiring students to ask questions, turn on cameras and make eye contact, and so forth as discussed by [9], but they might also need to change the lesson aspects to meet learning needs that are not addressed by the aforementioned considerations (such as changing from three to two main content objectives).

Additionally, educators may need to model desired behavior when teaching format changes. As the format changes, strategies for content delivery and student engagement might also take a new form. In this type of environment, planning can no longer solely focus on learning activities, but also encompass the structure of the learning environment in an online setting. Traditional in-person classroom course design focuses on the pedagogy, content knowledge, instructional strategies, and other well researched areas. Switching learning environments creates the need to focus on the infrastructure as well, which is an added burden to educators that in the past have not needed to be adept in this area as well. Taking a preemptive approach to plan alternative instructional delivery combinations for lesson aspects can offer continued flexibility in future course redesign efforts and making in-the-moment, necessary, teaching changes.

The lessons learned from this LIFT research study, center around creating a space for learning—online and in-person, or both, rather than centering around traditional pedagogical content knowledge in traditional or online spaces. The authors' research question asked, "How does an interdisciplinary undergraduate grant team, including a late-term preservice K–12 teacher, prepare science outreach lessons for a broad spectrum of potential delivery modes?" In the spirit of *lessons learned*, the authors offer the following potential options (or recommendations) for secondary and post-secondary STEM educators planning courses subject to changing formats and social distancing constraints:

(a) Move lecture and content instruction online or into a hybrid scenario using pre-recorded videos and podcasts. These can be viewed before, during, or after class depending on the needs of the activity and can be prepared in advance of the course.
(b) Use synchronous class discussions to webinar (e.g., Zoom) or asynchronous discussion format and encourage/require students to ask questions and respond to each other. This promotes interaction and provides a space for community building.
(c) Offer step-by-step instructions for student at-home experiments and activities as soon as possible. Providing resources, such as instructions as soon as they are created is a mechanism to allow maximum student engagement and response time. Since students working at home are often following a non-traditional school schedule, and in a non-traditional school space, providing extra time to engage with materials is of the utmost importance.
(d) Provide access remote STEM learning opportunities (such as remote telescope observations, PhETs, and more) to allow students the time and space to interact with STEM experiences from the place where they are trying to learn.
(e) Apply [24] considerations for authenticity, collaboration, and personalization along with situatedness, contextualization, conversation, data sharing, customization, and agency.

Although the authors offer suggestions, there is no one answer or one uniform way that every educator and every student respond to shifting teaching modalities. Each person has a different set of constraints and all of those must be taken into consideration; thus, instructional adaptations should be previously prepared and fluid for flexible teaching.

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Article

The Impact of the COVID-19 Pandemic on Teaching Mathematics and Students' Knowledge, Skills, and Grades

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Abstract: As a consequence of the COVID-19 pandemic and measures to secure public health, many processes have moved to the online space. The educational process is not an exception. Our main goal, which is presented in this article, was to re-design the educational process from face-to-face to distance learning in the Mathematics 1 course at the Technical University of Košice. This article describes our approach to teaching, observations, and experience. This case study examines three factors: Firstly, the impact of distance education on overall assessments of students. Using descriptive statistics, the results of student evaluations were compared from the overall assessments for the last six academic years. It was found that distance learning does not affect excellent students and eliminates the number of students who do not pass. Secondly, the participation of students during online lessons, and thirdly, the use of electronic materials. The questionnaire survey and the data from the learning management system Moodle were used to examine the second and third factors. Descriptive statistics were used to describe the questionnaire survey data (frequencies, percentages and averages). An exploratory factor analysis was performed in order to assess the underlying key concepts regarding student evaluation of the teaching process. The exploratory factor analysis confirmed that this questionnaire followed the four key concepts.

Keywords: distance education; mathematics; online teaching materials

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1. Introduction

With the entry of a new generation of students (Generation Z) to the school environment, the need arose to create online materials to support teaching. With the arrival of rapid digitalization in the school environment, several questions have arisen associated with the manner and suitability of the technologies and tools used. The impact of these changes on pupils and students is further examined.

To enhance an otherwise dull rewrite of textbook content into a digital representation, animations can be a great way to light up the digital material. Numerous studies at various education levels have shown that introducing animations into study materials effectively explains the presented topics and captures learners' attention [1–3]. However, can they make a difference in the realm of university-level mathematics? Azman et al. [4] investigated the use of 2D and 3D animations created in Computer Algebra Software (CAS) for explaining the continuity of 2D functions and Taylor polynomials in 3D. They concluded that it can effectively relay the message of the presentation and demonstrate crucial concepts that cannot be otherwise explained by text or graphics. Recently, the prevalent nature of dynamic content on the web has inspired mathematics educators to experiment with JavaScript and its powerful visualization libraries such as GeoGebra. On the topic of Taylor polynomials, Lindner [5] created an interactive explanation embedding GeoGebra's JavaScript reactive element within a HTML website.

Most students agree that using software as an aid in the learning process is impacting them positively [6]. Nowadays, successful engineers cannot be without computational skills,

which they acquire from solving problems in computational software. An example of such software for conveniently expressing, analyzing, modeling, and solving problems is MATLAB, which has been implemented into mathematics courses at many universities [6–13].

1.1. Redesign of The Mathematics Course

Mathematics is a systematic scientific discipline, and this systematic nature is the basis for education. Its content is integrated into the educational process from kindergarten to university. The mathematics curriculum is adapted to the specific focus of schools (high school and university). Mathematics courses are included among the compulsory subjects, the teaching of which is usually realized in the first semester of a bachelors' study at a technical university. The mission of education is to develop the correct mathematical language, which is then used for problem solving in specialized subjects. This is the basic goal, which is adopted in every part of the educational process, whereas the emphasis is on the correct idea of mathematical concepts, objects, and the relationships between them.

1.1.1. Process of Distance Education

Significance has been attached to the overelaborate and complex nature of online materials using several types of ICT, even more so during distance education.

In order to re-design Mathematics 1 course for distance education, it was necessary to choose a practical Learning Management System (LMS), which provides integration with other standard university information systems (in our case, the MAIS system).

The LMS system Moodle was chosen for distance education in the present Mathematics 1 course. Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open-source online learning management system created by Martin Dougiamas in 2002 [14]. It is used in a wide range of schools and educational institutions across the world. This learning platform has a wide range of features for teachers and students. Moodle provides a modern, easy-to-use interface for teaching materials, collaborative tools, and online activities; convenient file management; notifications; and administrative features [14]. Students have access to course learning materials, tests for continuous automated assessment, forums, lessons, quizzes, and wikis; they can upload their work, track grades, and much more [14].

Online study materials were available for students throughout the semester on the Moodle system. New online materials were added to the topic every week, including the following:

- Video lectures;
- MATLAB video tutorials;
- MATLAB Live Scripts;
- Online collection of solved examples;
- Visualizations of examples:
    - Animation of solving examples in LaTeX;
    - Presentations with solutions of examples in the JavaScript.

Considering the specifics of teaching mathematics, the existence of online materials alone is not sufficient. We agree with the opinion published in [15] that teaching mathematics is a dynamic and creative process that requires the physical presence of students in a lecture hall for instantaneous fine-tuning of the development of a lecture according to the reaction of the students. This missing interaction can manifest itself, for example, in the incorrect understanding of individual concepts and a subsequent inaccurate or incomplete solution to problems on the mathematical basis. Without the teacher–student interaction, these misconceptions would only be diagnosed during the evaluation of students.

Therefore, the teacher–student interaction was maintained and realized in the form of regular online meetings by using the following communication system:

- Online lectures (two lessons with all students enrolled in the course);
- Online exercises (three teaching hours for students divided into groups based on the group's study focus; maximum 40 students present in the group).

The communication system from the teaching point of view had to satisfy the following requirements:

- User-friendly design.
- High number of invited participants in one video call (approx. 300 participants).
- Multi-platform solution.
- Possibility of fully functional video conferencing on several devices (PC, tablets, smartphone—from the point of view of guests and participants).
- Possibility to create a schedule of online meetings for a prolonged period (13 weeks) with the possibility of automatic reminders.
- Possibility to share a desktop computer and tablet for host and participants.
- Possibility to use a blackboard with handwritten notes.
- Possibility to record part of the lesson, only available to the host.
- Possibility to export the list of participants after the end of a lecture.
- Possibility of creating groups (approx. 40 participants) and sharing documents before the online lecture.

At present, there are a lot of different video conferencing systems. The Technical University of Košice purchased a license for two communication systems: MS Teams and Cisco WebEx Meetings. Considering the requirements described earlier, the Cisco WebEx Meetings software was chosen. This system meets all of our requirements for education, and its added value is security. Hence, it is used frequently in business.

1.1.2. Evaluation of Distance Education

Continuous tests are a diagnostic tool to verify gained mathematical knowledge at the first and second levels of understanding. Continuous and final tests were realized in the LMS system Moodle after student registration in the system using the unique login and password of the student. The tests were generated based on key concepts from prepared tasks. Therefore, each student had a different, individual series of tasks. Students of same group had the tests available at a prearranged time, usually before the exercise.

After the end of the semester's teaching part, a final student evaluation was performed by means of a final test. This test consisted of tasks where answers had to be created.

A unique test was generated for each student from the task bank based on the teacher's predefined requirements. After calculating the task, the students wrote their answers in the online test and attached a photo of a handwritten solution to each task.

Finally, the test closed automatically in the system after a set time limit of 120 min.

If the students completed the tasks earlier, they had the option to close the test from their profile and then log out of the system.

Creation of online study materials for the Mathematics 1 course began in 2008 and experienced accelerated development in the years 2014 to 2019. These materials were reworked, thematically expanded, and improved with the arrival of modern technologies. With the onset of the COVID-19 pandemic and the request to change the teaching method from face-to-face to distance learning, we were prepared from the point of view of the quantity and quality of online materials and the technological and technical equipment for immediate transfer to an online space.

1.2. Computational Software and Online Study Materials

In addition to computational software that is used for practicing what students have learnt, the theoretical fundamentals for mathematics courses in the times of online distance learning are often presented in static documents published on the web in PDF format or static HTML websites. They provide a classic, written, non-dynamic form of presenting the information. However, in many higher-level mathematical courses, students are expected to know how to manipulate and work with higher-dimensional objects and concepts.

Therefore, anything that helps with better presenting these concepts than in a static, two-dimensional form, often hiding or not communicating clearly enough the dimensionality of the problem at hand, is of great benefit for the learner. A better understanding can be built by implementing better visualization methods into study materials. Visualization supports the learning and understanding of concepts when analyzing and solving problems. It can improve or even replace some verbal explanations [13]. Integrating visualization into static documents is a substantial enhancement, but the non-dynamicity of the medium is a big limiting factor. Therefore, for the creation of online study materials used in online distance learning, beside the classic approach of creating materials with static content, we explored three additional approaches for transforming static documents into interactive and dynamic ones, while using gained degrees of freedom to design a rich learning environment.

The digital study materials that we implemented can be divided into the following categories:

1. Materials with static content;
2. Materials with static animations;
3. Materials with dynamic, reactive elements;
4. Editable materials with editable code.

To be more specific, they are (1) solved problem sets distributed on an online blogging platform, (2) authoring documents with static animated elements in LaTeX, (3) reactive documents with JavaScript, and (4) Live Scripts with MATLAB Live Editor.

1.2.1. Materials with Static Content

Blogger is a free Google service for creating blogs [16] that supports multiple languages. It offers free web hosting with easy administration and integrates MathJax [16].

Therefore, Blogger was a perfect candidate for creating online material with static content for the Mathematics 1 course (Figure 1) [17].

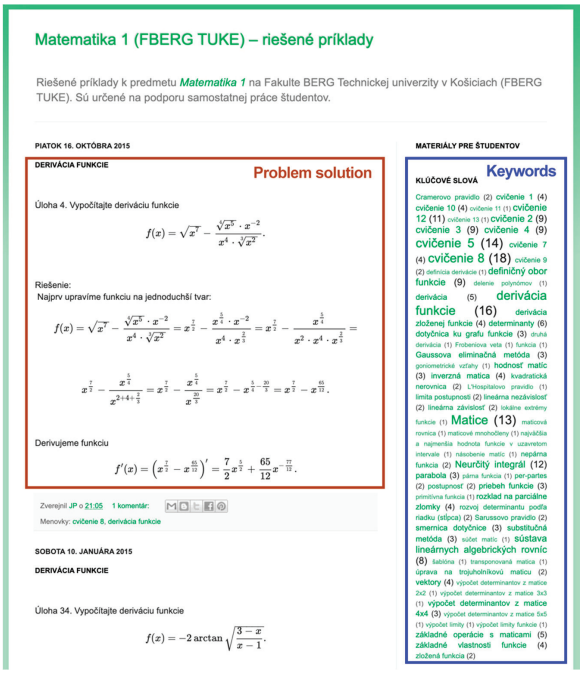

Figure 1. Solved problem sets on Blogger platform in static material form.

The blog contains examples with detailed comments and references to the basic properties and definitions needed for the successful solution of mathematical problems. The examples are solved by the most used methods because our goal was to demonstrate different approaches that lead to the correct solution. The selected tasks correspond to the lectured themes and are sorted by keywords acquired in the course.

1.2.2. Materials with Static Animations

In materials with static animations, an element is animated from one state to another automatically. The user can stop it and control the evolution manually (forward or backward in time). They are different from dynamic animations in that the latter are typically triggered by some event or user interaction.

One of the technologies for authoring such materials is LaTeX. It is free software created by Leslie Lamport in 1985 as a document preparation system for high-quality typesetting [18]. LaTeX is popular in academic communities, mainly for writing scientific papers, as the low-level TeX language developed by Donald Knuth, on which LaTeX is built, was written with an emphasis on the precise presentation of mathematical formulas. Many of its commands, macros, and packages for typesetting and embedding images, multimedia, tables, etc., provide the ground for producing several types of documents (articles, presentations, journals, books, etc.). Raw LaTeX source is usually compiled into Portable Document Format—PDF.

To enrich static PDF files with animated elements, it is possible to leverage the Animate package. Under the hood, it uses JavaScript to drive presentation-style animations created from sets of vector or raster graphics, embedding them together into compiled documents [19]. Graphical representations that are used for animations can be created with the PGF/TikZ package, which is a language for creating graphics in LaTeX [20] (Figure 2).

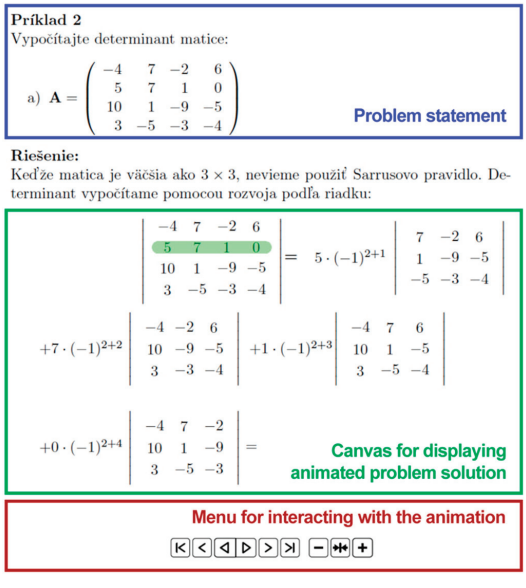

Figure 2. Static animations created with LaTeX.

1.2.3. Materials with Dynamic, Reactive Elements

With the help of JavaScript, a scripting language used for developing dynamic elements inside HTML documents, it is possible to create engaging and visually appealing online materials. When the document is loaded as a page in a web browser, it creates a Document Object Model (DOM) from that page, which can be viewed as a tree of objects describing

all of the page's HTML elements [21]. JavaScript provides an API for manipulating an otherwise static representation of a DOM and allows for changing its parts on the fly.

This dynamic behavior can be exploited in various ways, including drawing graphical representations of mathematical concepts. These can be static but also fully dynamic, animated automatically, or interactive with user input. Specifically, for creating mathematical visualizations and animations, the JavaScript ecosystem has many libraries available. WebGL (Web Graphics Library) [22], math.js, and MathBox.js [23] are widely used. For 3D visualizations, there is the Three.js library that is built on top of WebGL [24].

When designing online materials (Figure 3), we took advantage of the dynamic behavior of JavaScript reactive elements to show an immediate connection between the mathematical language and the visual representation of solved problems. Mouse interactions with mathematics content written with LaTeX triggers a change in various parts of the web page, mainly emphasizing the graph parts by changing their color or thickness. This way, students gain a better understanding of the underlying mathematics.

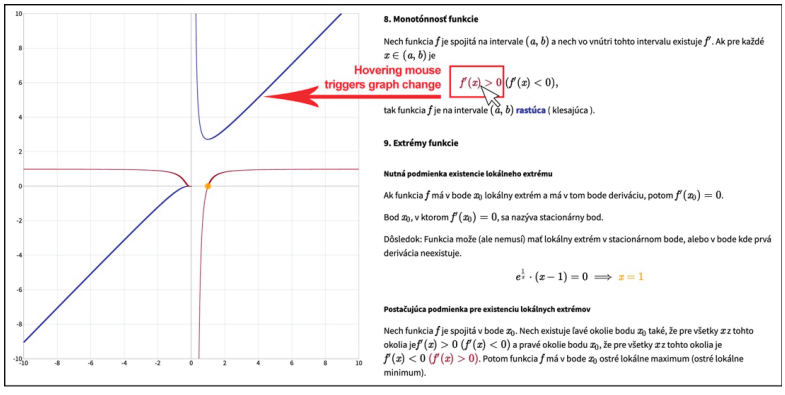

Figure 3. Reactive elements created with JavaScript.

1.2.4. Editable Materials with Editable Code

Interactive learning material is important to support students to actively engage with the learning material. MATLAB Live Editor is a feature introduced in version R2016a. It provides an interactive environment in the form of interactive documents resembling Jupyter notebooks, which are often used by data analysis practitioners. Live Scripts combine MATLAB code with formatted text, equations, and images (Figure 4).

Our main goal was to change the education process from face-to-face to distance learning in the Mathematics 1 course at the Technical University of Košice. In this article, we describe process of change and our observations, experience, and conclusions on the basis of the data obtained from distance education.

This goal is specified in the following research questions:

- RQ1: What impact does distance education have on the evaluations of the students in the Mathematics 1 course?
- RQ2: Which online materials did students use most frequently?
- RQ3: Which mathematical topics are most interesting for students?
- RQ4: Which mathematical topic is the easiest for students, and which is the most difficult?
- RQ5: What is the relationship between the easiest topic and using online materials?
- RQ6: What is the relationship between the most difficult topic and using online materials?

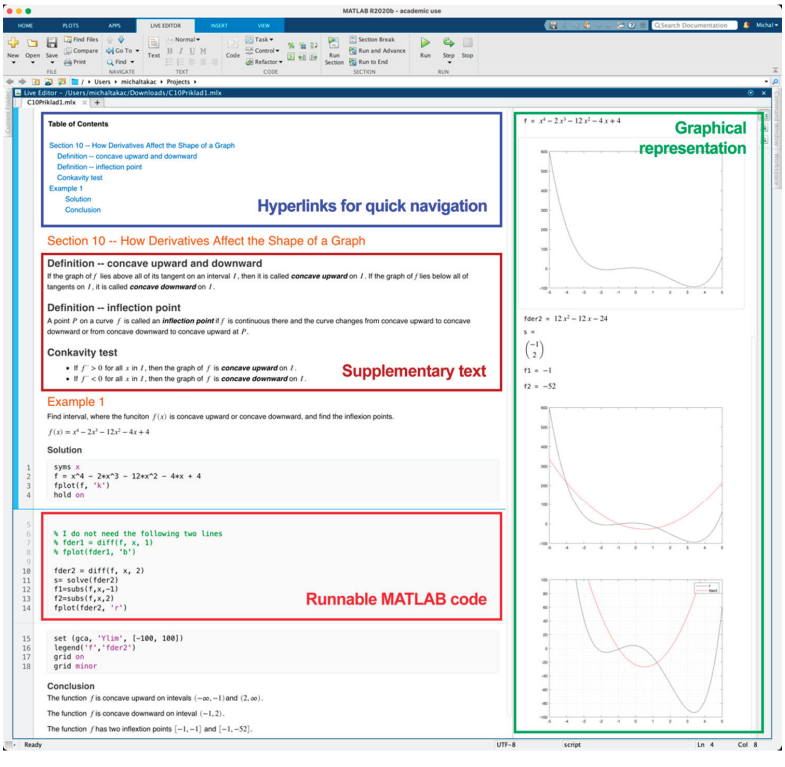

Figure 4. MATLAB Live Editor with editable live script.

2. Materials and Methods

As mentioned above, our goal was to change the education process from face-to-face to distance learning in the Mathematics 1 course at the Technical University of Košice and to analyze the impact of this change from the perspective of the students and the teachers.

A total of 252 first-year bachelor students were enrolled in the Mathematics 1 course in the academic year 2020/2021. There were students from nine different study programs. In terms of gender, 69% of the students were male and 31% were female. The students obtained an average of 18% from the continuous assessment and 55% from the overall assessment.

To answer the research questions, the overall assessment of students was analyzed, and a questionnaire was developed.

- *Analysis of overall assessment of students in this academic year and comparison of the results with the five previous years (RQ1)*

The analysis compared the overall assessment results of students who completed the Mathematics 1 course during the last five years, with evaluation of students' overall assessments in this academic year.

A student passed the continuous assessment when they obtained at least 16% out of 30%. A student passed the final assessment when they obtained at least 36% out of 70%. The overall assessment is the sum of the continuous and final assessment obtained during semester.

Grading system:

- A (91–100%)—Outstanding/excellent work;
- B (81–90%)—Good/competent work;
- C (71–80%)—Adequate/reasonably satisfactory work;

- D (61–70%)—Less acceptable work;
- E (60–51%)—Minimally acceptable work;
- FX (under 50%)—Inadequate work.

Data were collected from 979 students' overall assessments (2020/2021—248; 2019/2020—182; 2018/2019—171; 2017/2018—147; 2016/2017—231). This analysis used descriptive statistics.

- *Questionnaire survey (RQ3—RQ6)*

The data were collected by an anonymous questionnaire survey via Moodle from bachelor students of the Mathematics 1 course after the winter semester in 2020/2021. The collected data contained 110 responses from students who passed the course.

The questionnaire was divided into three parts. The first part looked into the participation of students in the online lessons (lectures and exercises) and their rating (Q1-Q4). The questions in this part used a five-point scale (5—always/excellent; 4—often/good; 3—sometimes/average; 2—seldom/poor; 1—never/N/A).

The second part focused on finding out how often students used/watched online materials/contents (Q5-Q9). The questions in this part used a five-point scale (5—always; 4—often; 3—sometimes; 2—seldom; 1—never).

The final part of the questionnaire examined whether students found the course topics difficult and interesting (Q10-Q12). In this section, the students could choose one of the topics.

All materials were stored or linked (online collection of solved examples, visualizations of examples) on Moodle. The data from the final part of the questionnaire were compared with the data from Moodle logs to find out how students had accessed study materials for given topics.

Descriptive statistics were used to describe the questionnaire survey data (frequencies, percentages and averages). Each question's data were presented as a pie or bar chart.

An exploratory factor analysis was performed in order to assess the underlying key concepts of students' evaluation of the teaching process. Nine questions from the first two parts of the questionnaire were analyzed. Factor analysis is a data reduction technique that seeks the set of latent underlying factors that summarize the essential information contained in the set of variables. The number of factors is usually smaller than the number of observed variables. Since the questionnaire items were measured on a Likert scale, we performed the analysis on a matrix of polychoric correlations. For this purpose, the package FACTOR was used [25].

3. Results

3.1. Success of Students in the Mathematics 1 Course

Student evaluations based on overall assessments for the last six academic years were compared (Table 1, Figure 5).

Table 1. Student evaluation based on overall assessments for the last six academic years; numbers are given in percentages.

Academic Year	A (100–91)	B (90–81)	C (80–71)	D (70–61)	E (60–52)	FX (<51)
2020/2021	3.23	4.03	12.90	29.84	31.85	18.15
2019/2020	3.74	3.21	13.37	16.04	21.93	41.71
2018/2019	4.68	2.34	9.36	12.28	21.64	49.71
2017/2018	3.40	6.12	10.20	21.77	18.37	40.14
2016/2017	0.43	2.16	6.49	19.91	22.94	48.05
2015/2016	0.47	4.19	10.70	17.21	28.37	39.07

These results show that the ample online support for distance education had an impact on the improvement of grades in the student evaluation. More students passed the final

test in the academic year 2020/2021. The distribution of individual evaluations changed only for marks D and E.

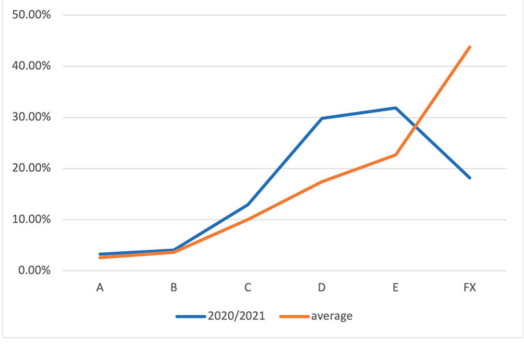

Figure 5. Comparison of overall assessment evaluations from the year 2020/2021 and the average marks from the last 5 years.

According to our findings, the change from face-to-face to distance education does not affect excellent students. It turned out that with sufficient online support, it is possible to observe a certain shift in knowledge and mathematical skills for students who previously had lower-level skills. The distance approach did not eliminate the number of disadvantaged students, although their number significantly decreased.

3.2. Questionnaire Survey

The questionnaire consisted of 12 questions (Table 2). The questions Q1-Q9 used a five-point Likert scale. Cronbach's alpha for the Likert-type scales showed that the questionnaire has acceptable reliability, $\alpha = 0.71$.

Table 2. Questionnaire.

Questions	Answers
Q1. Did you participate in online lectures? Q3. Did you participate in online exercises?	5—Always 4—Often 3—Sometimes 2—Seldom 1—Never
Q2. How do you rate online lectures? Q4. How do you rate online exercises?	5—Excellent 4—Good 3—Average 2—Poor 1—N/A
Q5. How often did you watch video lectures? Q6. How often did you watch videos of solved examples in MATLAB? Q7. How often did you use MATLAB Live Scripts? Q8. How often did you use online collection of solved examples? Q9. How often did you use LaTeX and JavaScript visualizations of examples?	5—Always 4—Often 3—Sometimes 2—Seldom 1—Never
Q10. Which topic did you find the most difficult? Q11. Which topic did you find the easiest? Q12. Which topic did you find the most interesting?	1. Vectors 2. Matrices 3. Determinants 4. Systems of linear equations 5. Functions of one real variable 6. Sequences, limit of a sequence 7. Limit of a function 8. Derivative of a function 9–10. Monotone, convex, and extrema 11. Sketch of the graph of the function 12. Integral calculus and its application

The first part (Q1–Q4) of the questionnaire was used to obtain information about participation in the online lectures and exercises (Figure 6). The results showed that 71.82% of the students participated in the online lectures every week (40%) or almost every week (31.82%), 21.81% had irregular attendance (16.36% sometimes and 5.45% seldom), and 6.36% never attended online lectures (Figure 6a). The average rating of online lectures was 73.27% (Figure 6c).

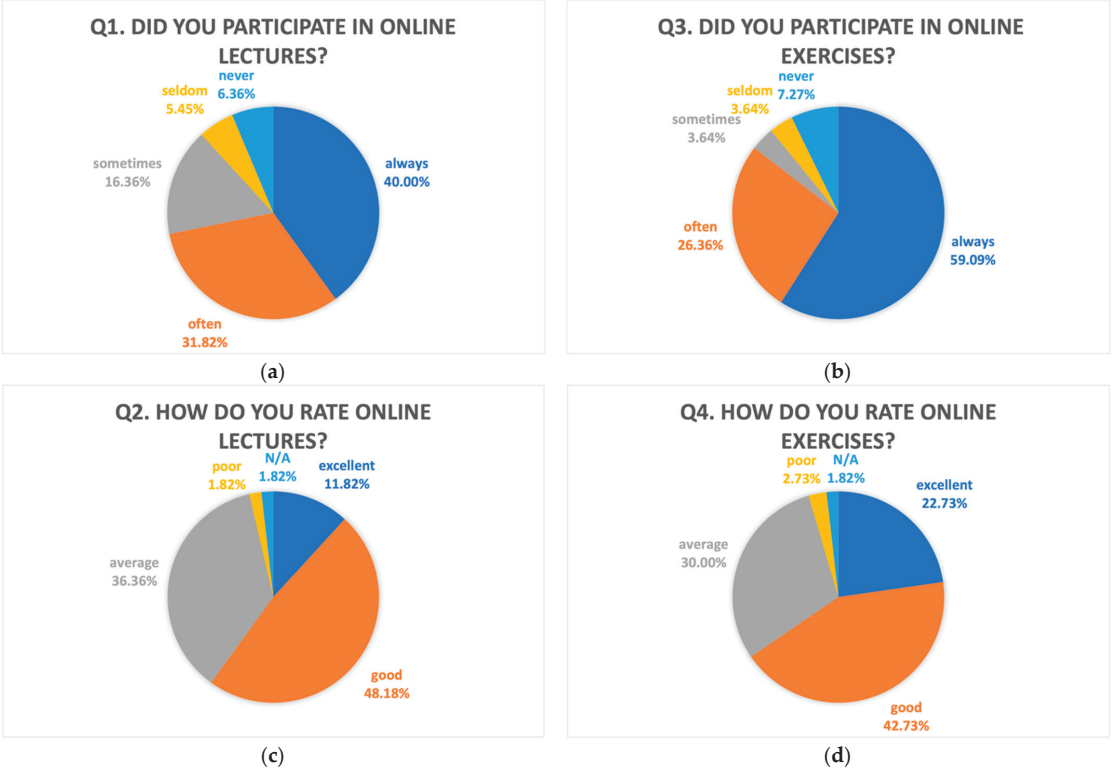

Figure 6. Questionnaire part 1: (**a**) Participation in online lectures; (**b**) participation in online exercises; (**c**) online lectures rating; (**d**) online exercises rating.

Online exercises had more regular attendance (85.45%, Figure 6b): 59.09% of the students participated every week and 26.36% almost every week, 7.28% of the students attended irregularly (3.64% sometimes and 3.64% seldom), and 7.27% of them never attended online exercises. The average rating of online exercises was 76.36% (Figure 6d).

The second part (Q5-Q9) of the questionnaire focused on how often the students used online content (Figure 7). The results showed that 70% of the students watched video lectures regularly (14.55% every week, 55.45% almost every week), 22.73% of the students watched them occasionally (12.73% sometimes and 10% seldom—for example, when they had not attended the online lecture), and 7.27% never watched video lectures (Figure 7a).

Videos of solved examples in MATLAB were watched by 47.27% of the students every or almost every week (20% always, 27.27% often), by 18.18% of them occasionally (10.91% sometimes and 7.27% seldom), and 34.55% of the students never watched these videos (Figure 7b).

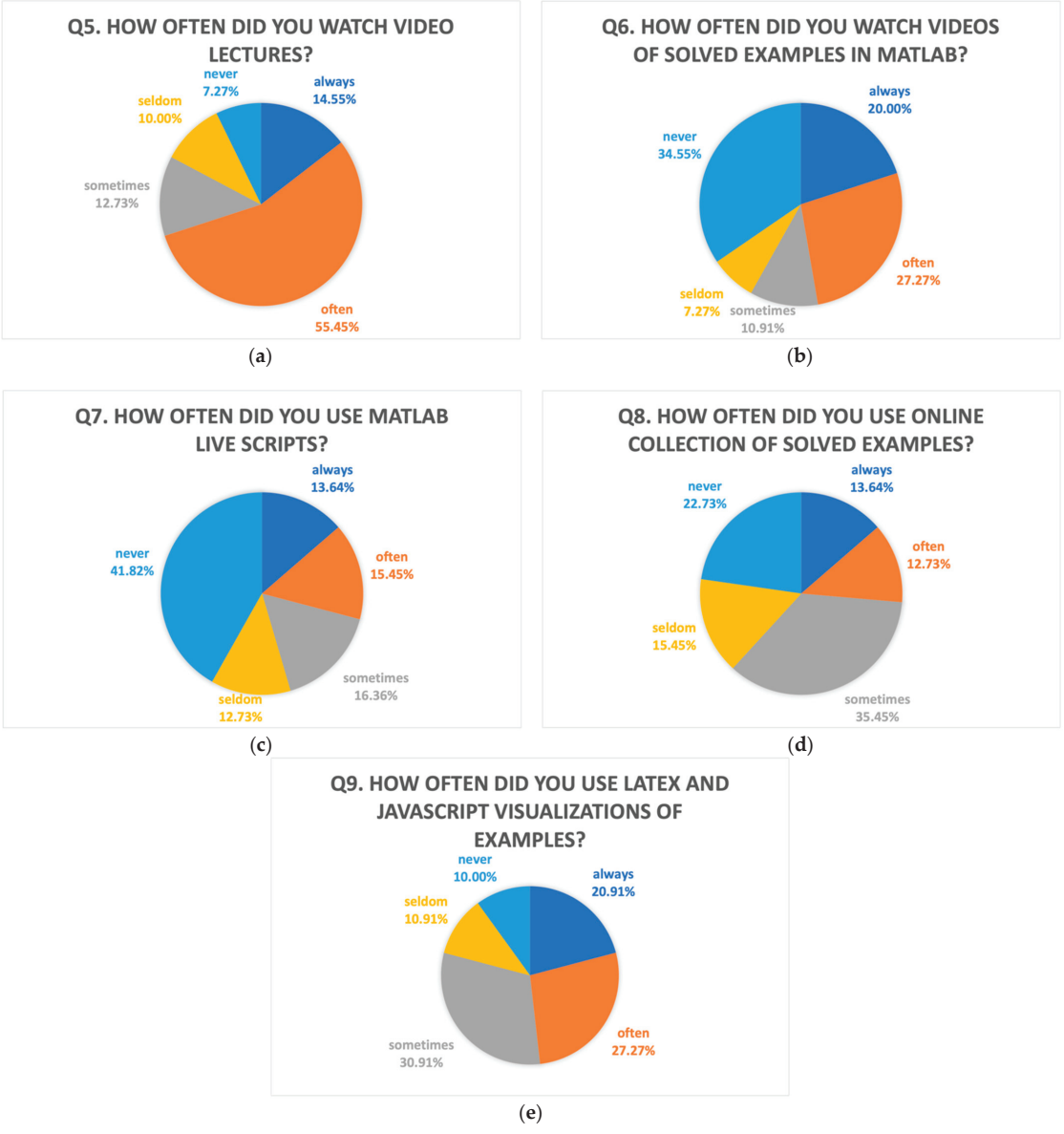

Figure 7. Questionnaire part 2: (**a**) Video lectures; (**b**) MATLAB video tutorials; (**c**) MATLAB Live Scripts; (**d**) online collection of solved examples; (**e**) visualizations of examples.

Similarly, MATLAB Live Scripts were used regularly by 29.09% of the students (13.64% always and 15.45% often), by 29.09% of them occasionally (16.36% sometimes and 12.73% seldom), and 41.82% of the students never used Live Scripts (Figure 7c).

The students' answers showed that 26.37% of them regularly (13.64% always, 12.73% often) and 50.9% of them occasionally (35.45% sometimes and 15.45% seldom) used the online collection of solved examples. The remaining 22.73% of the students never used this collection (Figure 7d).

LaTeX and JavaScript visualizations of examples were regularly used by 48.18% of the students (20.91% always, 27.27% often); 41.82% of them used these visualizations irregularly (30.91% sometimes and 10.91% seldom), and 10% of them did not use this online content (Figure 7e).

The third part (Q10-Q12) of the questionnaire collected answers about the most difficult, the easiest, and the most interesting topics (Figure 8). The students answered that the most difficult topics were (Figure 8a) (12) integral calculus and its application; (9–10) monotone, convex, and extrema; and (11) sketch of the graph of the function.

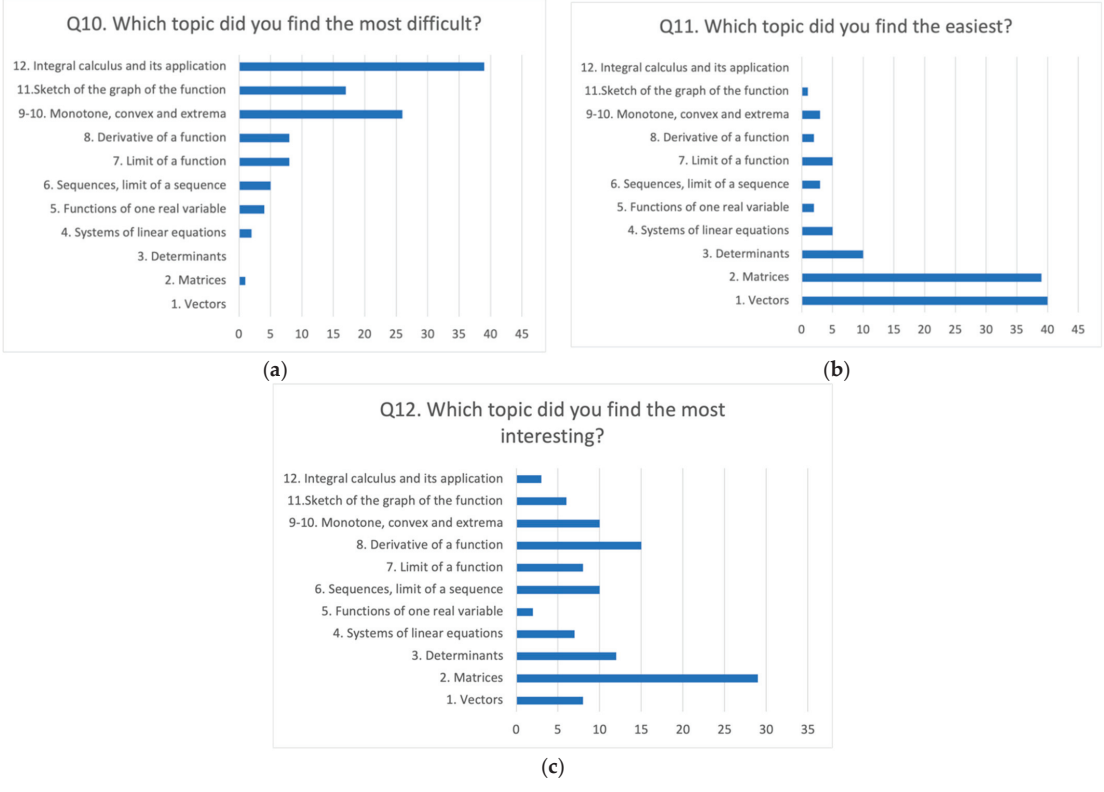

Figure 8. Questionnaire part 3: (**a**) The most difficult topic; (**b**) the easiest topic; (**c**) the most interesting topic.

The easiest topics were (Figure 8b) (1) vectors, (2) matrices, and (3) determinants. The most interesting topics for students were (Figure 8c) (2) matrices, (8) derivative of functions, and (3) determinants.

We analyzed Moodle logs to find out how students had accessed study materials. It is possible that students can access those link resources directly without leaving any trace in Moodle logs.

The easiest topics, 1, 2, and 3, had the most accesses to video lectures (Topic 1—989 accesses; Topic 2—701 accesses; Topic 3—255 accesses) and MATLAB Live Scripts (Topic 1—703 accesses; Topic 2—288 accesses; Topic 3—149 accesses).

The most difficult topic, 12, had more accesses to video lectures (138 accesses) and the online collection of solved examples (82 accesses). The more difficult topics, 9–10 and 11, had the most accesses to visualizations of examples (Topic 9–10—189 accesses; Topic 11—97 accesses) and the online collection of solved examples (Topic 9–10—186 accesses; Topic 11—126 accesses).

The most interesting topics, 2 and 3, had the most accesses to video lectures (Topic 2—701 accesses; Topic 3—255 accesses) and MATLAB Live Scripts (Topic 2—288 accesses; Topic 3—149 accesses); topic 8 had the most accesses to visualizations of examples (121 accesses) and an equal number of accesses to video lectures and the online collection of solved examples (98 accesses).

Exploratory Factor Analysis

In order to verify the validity of a factor analysis on our data, a Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity were first conducted to verify if the dataset was suitable for the factor analysis. Both tests are used to measure the sampling adequacy and to determine the factorability of the correlation matrix. Both Bartlett's test ($c2 \times (36) = 386.4$, $p < 0.001$) as well as the KMO test (=0.601) indicated that the factor analysis can be performed on the data. Based on a parallel analysis, three factors were recommended; however, after examining three- and four-factor solutions, we finally extracted four factors (these factors explained 95.9% of variability). The communalities for all variables were greater than 0.5, except that of Q5, where the communality was 0.351. The communality of a given variable is an estimate of the percentage of variance of that variable explained by all factors found. We also analyzed the data without this question; however, no improvement was achieved by means of overall fit, and the interpretation of factors was similar to that of the four-factor model with this item. Since this question fits the extracted factor, "Factor 3—Use of online materials", we decided to leave this question in the solution. The extracted factors, questions, and question loadings of the rotated factor matrix are summarized in Table 3, where only loadings greater than 0.4 are shown.

Table 3. Factor loadings.

Question	Factor 1	Factor 2	Factor 3	Factor 4
Q1. Did you participate in online lectures?	0.675			
Q2. How do you rate online lectures?		0.734		
Q3. Did you participate in online exercises?	0.977			
Q4. How do you rate online exercises?		0.992		
Q5. How often did you watch video lectures?			0.472	
Q6. How often did you watch videos of solved examples in MATLAB?				0.945
Q7. How often did you use MATLAB Live Scripts?				0.926
Q8. How often did you use online collection of solved examples?			0.717	
Q9. How often did you use LaTeX and JavaScript visualizations of examples?			0.805	

Factor 1 (F1) is correlated most strongly with participation in the exercises (0.977, Q3) and participation in the online lectures (0.675, Q1), so this factor describes "Participation in the online lessons". Exercise rating (0.977, Q4) and lecture rating (0.734, Q2) have positive loadings on Factor 2 (F2), so this factor describes "Satisfaction with the online lessons". Factor 3 is correlated with use LaTeX and JavaScript visualizations of examples (0.805, Q9) and the online collection of solved examples (0.717, Q8) and, to a lesser extent, watching video lectures (0.472, Q5), so this factor describes "Use of online materials". Factor 4 is correlated most strongly with watching videos of solved examples in MATLAB (0.945, Q6) and use of MATLAB Live Scripts (0.926, Q7); therefore, it describes "Use of MATLAB-related online materials".

The exploratory factor analysis confirmed that this questionnaire (Q1-Q9) followed the next four key concepts (Figure 9):

- Factor 1 (F1)—Participation in the online lessons;
- Factor 2 (F2)—Satisfaction with online lessons;
- Factor 3 (F3)—Use of online materials;
- Factor 4 (F4)—Use of MATLAB-related online materials.

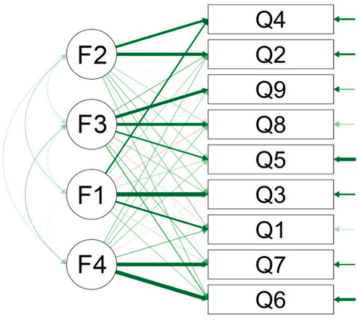

Figure 9. Path diagram.

Four of the questions (Q1-Q4) were related to distance learning, including participation in online lessons (F1) and satisfaction with them (F2). The remaining five questions (Q5-Q9) focused on self-education using supporting online materials. This concept was divided into two parts: MATLAB-related online materials (F4; Q6-Q7) and other online materials (F3; Q5, Q8–Q9).

4. Discussion

RQ1: What impact does distance education have on the evaluations of the students in the Mathematics 1 course?

Despite the significantly better evaluations of students in 2020/2021, it is impossible to declare that distance education is more efficient than face-to-face education.

The fundamental drawbacks of the diagnostics of received knowledge, abilities, and skills during distance education are as follows:

- It is not possible to verify the identity of the student due to GDPR;
- It is not possible to ensure the same conditions for all students.

A positive aspect of the need for evaluation during distance education is the preparation of a lot of tasks used to assess students' knowledge, skills, and abilities. It will be possible to use bank tasks even after returning to face-to-face education.

RQ2: Which online material did students use most frequently?

The answers from the questionnaire were summarized, rated from 5 to 1 (5 means al-ways, 1 means never). Subsequently, the average scores and percentages of students who watched/used individual material at least once were calculated (Table 4). Figure 10 shows the order of individual materials' use according to their average score.

Table 4. Frequency of usage of online materials.

Online Material	At Least Once	Average	Average Score
Video lectures	92.73%	72.00%	3.60
MATLAB video tutorials	65.45%	58.20%	2.91
MATLAB Live Scripts	58.18%	49.20%	2.46
Online collection of solved examples	77.27%	55.80%	2.79
Visualizations of examples	90.00%	67.60%	3.38

RQ3: Which mathematical topics are the most interesting for students?

The most interesting topics for students were topics 2, 8, and 3—matrices, derivative of functions, and determinants, respectively. This result was surprising. From our experience, students consider the content of the first part of the Mathematics 1 course (Linear Algebra) easier. Students do not consider the content of one real variable's function to be simple, which may be the reason for its unattractiveness. From this point of view, it is surprising to find that derivative of functions was among the most interesting topics.

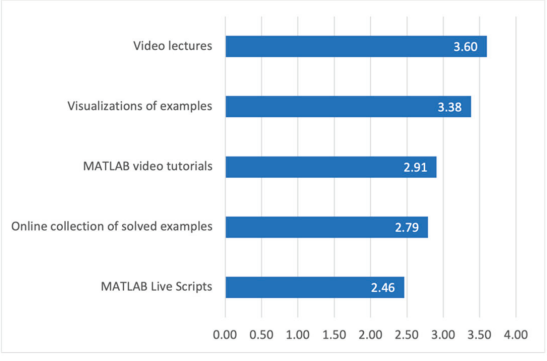

Figure 10. Average score.

RQ4: Which mathematical topic is the easiest for students, and which is the most difficult?

Students answered that the most difficult topics were 12, 9–10, and 11—integral calculus and its application; monotone, convex, and extrema; and sketch of the graph of the function, respectively. The easiest topics were 1, 2, and 3—vectors, matrices, and determinants.

Students described the first topics of the semester (Linear Algebra) as the easiest ones and the last topics of the semester (functions of one real variable—differential and integral calculus) as the most difficult ones. This answer of students was expected. For teachers, it is also a signal that these topics will receive more attention from the perspective of preparing different electronic materials.

RQ5: What is the relationship between the easiest topic and using online materials?

RQ6: What is the relationship between the most difficult topic and using online materials?

The most difficult topic, 12, had more accesses to video lectures and the online collection of solved examples. The more difficult topics, 9–10 and 11, had the most accesses to visualizations of examples and the online collection of solved examples.

According to our findings, students focused on video lectures and MATLAB Live Scripts while studying easy topics. For difficult topics, they focused on solving examples and used the online collection of solved examples, visualizations of examples, and also video lectures. Although they had online lectures and exercises, they still studied the online materials. We must also take into account the enthusiasm at the beginning of the semester and exhaustion at the end of the semester.

As mentioned above, it is possible that students could have accessed those online resources directly without leaving any trace in Moodle logs. For example, the online collection of solved examples had over 11,000 visitors/accesses during the reporting period (Figure 11).

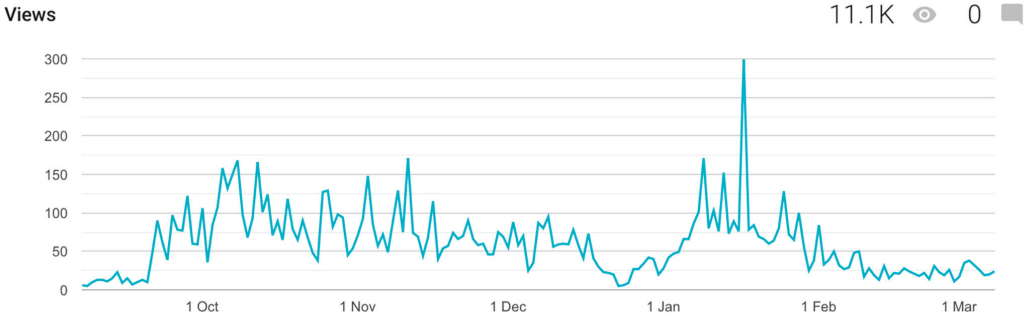

Figure 11. Blogger report.

4.1. Experience of Teachers with Distance Education

Even with the maximum prearranged online materials, continuous video meetings with students, and continuous automatic testing, distance education of a general subject is very time consuming. Despite teachers and students' extraordinary efforts, the teacher cannot directly intervene in the activities of multiple students at the same time. Another problem is students' insufficient technical accessories and unreliable Internet connections, which often fail due to adverse weather conditions. It is necessary to realize that students study from home, often in the remote areas of Slovakia or foreign countries.

4.2. Comparison to Related Work

The COVID-19 pandemic has multiplied the number of education studies dealing with distance education, online education, and e-learning.

The main focus is accented on the psychological effects of the pandemic on students and teachers and their overall readiness to change education [26,27].

Other types of studies deal with providing distance education from a technological point of view, including the present study.

When comparing results of the impact of online education, we observed a similar phenomenon as that in the study [15]:

- Students prefer to interact with the teacher through online streaming;
- Students prefer writing on the board.

The requirements of our students were the same. Interactions were made using online video conferences with students. Live writing during lessons was realized by connecting an online whiteboard (pen and tablet).

In contrast to the study [28], we have not identified the determinants of online effective learning, but rather the effectiveness of education was measured only on the basis of education results.

4.3. Future Plans

This case study demonstrated the scope for future research in distance education. We believe that the analysis of mathematical topics from the student point of view will bring more accurate results regarding the benefits and limits of distance education. Therefore, it is necessary to make the following changes.

- Use series of questions for students every week:
    - Choose the material that you are using during studies this chapter.
    - Choose the topic that is the most difficult for you in this chapter.
- Concentrate all materials only in the Moodle system without the possibility of other access to the electronic materials.
- Use Moodle learning analytics to predict or detect unknown aspects of the learning process based on historical data and current behavior.
- Use non-anonymous questionnaires.
- Examine the relationship between the answers to the questions and the final marks of the students.

At universities where the Python language is used for teaching introductory programming courses, advanced topics in mathematics, physics, and other technical subjects, it is useful to capitalize on it and use a Python environment such as Jupyter Notebook (JN) for teaching mathematics. For illustration purposes, it has been practiced for teaching the Mathematics course at the Department of Engineering at the University of Cambridge. JN is an open-source web application for creating and sharing online materials that contain live code, mathematical expressions written in LaTeX [29], visualizations, and narrative text. It is very similar to MATLAB Live Scripts.

5. Conclusions

Since the 1980s, the pros and cons of online education have been widely discussed. The debate has divided the scientific community into two camps: those who advocate for online education and those who are followers of classical, face-to-face education. With the new generation of students, a certain consensus has been adopted because online education is a suitable complement to traditional education, but the former cannot fully replace the latter.

The current situation leaves no room for this controversy. It opens up another strong topic: How can online distance learning be prepared so that it meets the primary learning goals? However, what is most important is to find an answer to the following question: How can the distance education process be managed so as to develop the knowledge, abilities, skills, and competencies of pupils and students and, thus, cultivate their personalities?

In our case, the quantity and quality of the prepared online materials were high, and therefore, the shift to distance education was relatively continual and without problems. Immediately after the end of the semester, we can say that students' results were satisfactory, and the use of online materials was above average.

The question of the stability of the knowledge and its capability to be used to solve other engineering problems is open at this point.

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Article

Experiences from COVID-19 and Emergency Remote Teaching for Entrepreneurship Education in Engineering Programmes

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Abstract: Education systems and institutions, often historically considered to be resolute, slow-moving entities transformed virtually overnight during the earlier stages of the COVID-19 pandemic, demonstrating nimbleness in adversity. This paper describes the first-hand experiences of teaching staff and students from a UK university which pivoted to emergency remote teaching for a core second-year module in engineering, focused on entrepreneurship. A range of methods are used including self-reflection, summative, formative, and focus-group student feedback. The paper provides an insight for readers who may be interested in the practical challenges associated with moving from an academic module typically delivered in a face-to-face learning environment accommodating a large student cohort (n = 177), to one that exists entirely in the digital domain. Our results show learning outcomes were fully met despite stark differences in quality of learning environments amongst students. Students reported benefits to remote learning because it offers a blended approach of both asynchronous content and synchronous sessions, with the latter enhancing engagement and providing structure to working weeks. Issues of presence emerged amongst group work: whilst it might be easier to confront some individuals for lack of contribution, it is also easier for those individuals to disengage. There was widespread support for the Microsoft Teams platform amongst students and staff but the former group reported this lacked a social environment in which relationships amongst team members could be nurtured informally, such as was experienced via social media.

Keywords: emergency remote teaching; engineering education; COVID-19; entrepreneurship education; distance learning; online learning

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1. Introduction

The COVID-19 pandemic caused untold disruption and misery throughout 2020, affecting the lives of millions of people globally. The profound impacts of the virus have shocked economies and societies in ways that have not been witnessed by many in living memory and with consequences that are likely to be felt by future generations. Education systems have of course not been immune and have required dramatic changes at very short notice across all levels of the learning spectrum, from school children to postgraduate research students. The speed of the reactions of educational institutions and their members is an admirable reminder of the flexibility and responsiveness of teachers and students in ensuring that the provision of a high-quality learning environment is maintained despite the adversity faced. Universities closed their campuses and whilst some international students remained in accommodation, the reality of continuing to provide higher education teaching and associated assessment became a high priority, for teaching, administrative, and technical staff alike virtually overnight.

This article aims to report on the experiences of engineering teaching staff from a United Kingdom university in the summer term (April to June) of academic year 2019/20, at the height of movement restrictions during the first Government-imposed lockdown.

This paper provides an insight for readers who may be interested in the practical challenges associated with moving from an academic module typically delivered in a face-to-face learning environment to one that exists in the digital domain. The research aims are as follows:

(i) Understand the lived experiences of engineering students undertaking distance learning during movement restrictions;
(ii) Uncover pedagogic challenges and benefits of ERT from the perspective of both students and teachers;
(iii) Suggest ways in which those challenges have been and could further be mitigated;
(iv) Identify aspects from ERT that in the context of teaching entrepreneurship to engineering students can continue to be used in the future.

Ambiguity surrounds the lexicon and definitions used when considering the differences between terms such as 'distance', 'online', 'digital', and 'remote learning', when taking account of characteristics of the learning environment and geographical interpretations of terms [1]. Distance learning is often considered to be a useful method of supporting adult education in particular due to the additional responsibilities adults may have in terms of parenting and employment. Distance learning is not a new concept of course and has been remarkably successful in education business models such as the Open University in the UK [2] for many decades, although distance learning is not without its reported barriers [3]. Some of these include "loss of student motivation due to the lack of face-to-face contact with teachers and peers, potentially prohibitive start-up costs and lack of faculty support" [3]. Further challenges have reportedly included the quality of instruction, cost effectiveness, misuse of technology, the role of technician and other support staff, and problems with operational efficiency of equipment [4].

The aforementioned terms generally refer to those where there is an implication of considerable planning in the design, execution, and evaluation of learning. For those who have pivoted to a different mode of delivery quite often in the space of a few weeks, such terms would be inappropriate. As others have posited [5–7], the terms adopted here refer to emergency remote teaching (ERT), which emphasises the urgency of the situation and the reactionary nature of dealing with a new mode of operation with relative quickness. ERT is a "temporary shift of instructional delivery to an alternative delivery mode due to crisis circumstances. It involves the use of fully remote teaching solutions for instruction or education that would otherwise be delivered face-to-face or in a blended or hybrid nature and that will return to that format once the crisis or emergency has abated" [7].

2. Engineering Education

The experiences of pivoting to ERT for university teaching in the context of COVID-19 are becoming increasingly more reported, helping others to benefit from a growing body of collective knowledge. This collection of topical research provides a rich and dichotomous snapshot of some of the effects of the pandemic. Many of the learning inequalities made acutely apparent as a result of COVID-19 have been widely reported [8,9] with the digital divide continuing to be a threat to addressing large scale equal access to education opportunities [6]. These social implications are grave and with increased prominence, it is hoped will motivate leaders and politicians to evoke widespread change. In keeping with the spirit of optimism, there have been considerable innovations in technology [10] as well as calls to make the future more socially responsible and environmentally just [11].

In terms of education of engineers, traditional curricula require tactile engagement through fabrication and testing, achieved by accessing workshops and laboratories with recent reviews describing the challenges associated with the student experience, quality assurance, assessment, and technologies [12] bought about by COVID-19. Student feedback has included fear and worry about their own health and the health of loved ones, difficulty in concentrating, disruption to sleeping patterns, decreased social interaction due to physical distancing, and increased concerns of academic performance [13]. This is shared in similar studies where causes of students' negative feedback of the situation include

network instability, unilateral interactions, and reduced concentration [14]. Consequences from mental health challenges during the pandemic could have long-term implications on student health and education [15].

Student responses to coping with what was the new education environment have been less well documented and have included strategies for self-discipline [16], use of appropriate technology to engage with instructors [17], and preferences over media type and length of sessions [18]. Authors have reported how teaching staff exercising compassionate and flexible pedagogy alongside effective communication has helped to support integrated engineering students [16]. The challenges with allied practical-based courses such as in the health professions present risks and opportunities [19] but the role of technology is commonly debated and often presented as having a lasting legacy [20,21], particularly the adoption of digital technologies [22]. Furthermore, practical course content has been successfully delivered through novel approaches to enable engineering students to be sent materials to undertake fabrication at home and fulfil learning outcomes [23]. Just as teachers have adapted, so too have students and successful mitigation strategies have been captured by overarching approaches to self-discipline.

A key feature of any undergraduate engineering programme should be that it helps enable people to work together by fostering and promoting teamwork. This aim has come about from both political influences as well as the increased demand by employers for graduates from technical disciplines to possess more transferable skills [24] and is a necessary component for accreditation awarded by the Professional Engineering Institutions (e.g., in the UK, the Institution of Mechanical Engineers and the Institution of Engineering and Technology) under the auspices of the Engineering Council [25]. The use of a range of strategies to achieve this has been investigated [26] and it was found that a combination of approaches brings benefits: embedded learning (where there is no direct reference to transferable skills), integrated learning (where skills are developed in parallel with core discipline knowledge) and bolt-on learning (where skills development is independent from core discipline). ERT may have an impact on the development of such transferable skills, especially where teamwork is a particular function of the mode of delivery. If students work together in groups online, does this better prepare them to be part of the global engineering workforce of the future?

2.1. Entrepreneurship Education for Engineers

Entrepreneurship education has seen significant growth in university curricula since the 1970s [27] with a recognition that the impact of capitalising on ideas will lead to economic growth at the company, regional, and national levels [28]. However, the role of entrepreneurship education is not without challenges, including measurement criteria [29] and impacts beyond courses such as its role in graduates, and their entrepreneurship [30]. Effective entrepreneurship education amongst engineering students has shown that this is a prime group for starting technology-related businesses at rates above the general population [31] and that entrepreneurial intention increases [32]. Authors have suggested that the role of entrepreneurship education in engineers should not be confined solely to reacting to economic growth and social returns but to provide engineers with the necessary skills to enhance their profile for a knowledge-based economy [33].

Within the Engineering degree courses offered at Lancaster University, a 15-credit, core-module undertaken by all Second-Year students (equivalent to UK FHEQ5) provides entrepreneurship education: Business Development Project (module mnemonic ENGR205). Taken from the Module and Programme Catalogue, the educational aims for subject-specific knowledge, understanding and skills are:

> *To expose students to a rich mixture of experiential learning opportunities that develop a wide range of transferable skills in the context of engineering entrepreneurship and innovation, with a particular focus on the development and use of business plans and marketing strategies.*

The educational aims for general knowledge, understanding and skills are:

To introduce students to a wide range of transferable skills in the context of entrepreneurship and innovation. To develop students' ability to think and argue critically, and plan and organise their work whilst being cognisant of team dynamics and operations.

The learning outcomes are provided in Figure 1.

Learning Outcomes: Subject Specific: Knowledge, Understanding and Skills

On successful completion of this module, students will be able to:

- Prepare a business plan;
- Discuss team dynamics;
- Discuss the requirements for entrepreneurial activity;
- Use appropriate terminology in developing business projects;
- Discuss relevant aspects of company finance, uncertainty in business ventures and how markets can be analysed;
- Analyse frameworks for marketing and the structure of a business plan;
- Analyse potential markets and sources of funding.

Learning Outcomes: General: Knowledge, Understanding and Skills

On successful completion of this module students will be able to:

- Apply a range of tools to assist in idea development and selection, including creativity tools such as brainstorming, business model canvas, etc;
- Effectively sell themself and an idea verbally and in writing;
- Discuss the benefits and problems of working in an interdisciplinary team;
- Analyse and solve engineering business problems with confidence;
- Demonstrate an understanding of the discipline that can be built upon towards further career progression.

Figure 1. Learning outcomes (subject-specific and general) for ENGR205: Business Development Project.

The module is delivered over an intensive five-week period during the summer term (April to June) and is made up of a number of lectures which include various guest speakers who share their experiences of business creation, entrepreneurial behaviours, and innovation management. The cohort size for academic year 2019/20 was 177. Students work in teams of between 10–12 which are assigned by the module convenor taking account of registered educational programme (e.g., degree discipline being studied) and level (i.e., Bachelors of Engineering (BEng Hons) or Masters of Engineering (MEng Hons) to ensure a semi-even distribution of skills, interests, and capabilities. In addition, there is also the option of selecting to participate in this module from outwith the core engineering student cohorts, including by students selecting engineering as a minor element of a Natural Sciences curriculum and international students undertaking a joint year abroad. This enables the benefits of non-self-selection such as knowledge spill over, cross-cultural learning relations, overcoming initial differences, and developing a strong team identity [34]. Such a method helps students prepare for workplace environments where being given a choice of colleagues with whom to work will not be an option for most. Moreover, it was found that students selecting their teammates has a very small impact on their level of satisfaction in the team [35]. Although the team size may be larger than optimum, the whole class size, available timetabling, and management and delivery over a short, intensive period of time by one module convenor within the final term of the academic year provides limited options to assign smaller team sizes.

The module is scheduled for the summer (UK) term of the academic year as assessment is 100% coursework-based, following the formal examination period completed in the weeks prior to delivery, providing the students with a somewhat different emphasis from their personal, focused study. Perhaps akin to the business and commercial world that the module emulates, it is conducted intensively over the course of four weeks, with a four-hour core session (with short breaks) scheduled each week for the whole class to participate. The fifth and final week is assigned for the completion and submission of assessed materials (see below). A structured lecture schedule is presented during the

weekly sessions, with the intention to provide the students with experiential learning, situational and commercial awareness, and innovation and entrepreneurial practice. Although the intention is to witness success—defined by the submission and pitching of a credible business proposition—by the completion of the module, it is important that through the formal lectures, many delivered by external speakers, emphasis is also placed upon 'failure', as this also constitutes a rich learning experience [36], developing resilience, tenacity and the motivation to try again [37]. Guest speakers do not therefore present solely on their professional acumen and business successes, but also on their journey through failure and disappointment. Lectures from guest speakers include, but are not limited to: 'Brilliant Business Ideas: Student Enterprise and Innovation'; 'Innovation in your Engineering Career'; 'Technopreneurship'; 'Pitching and Presentation Techniques'; 'Industry 4.0: A Once in a Generation Opportunity'; 'Patents vs Innovation'. These supplement lectures covering core learning and material from the module convenor: 'Idea Generation'; 'Venture Planning'; 'Business Model Generation'; 'Venture Creation'; 'Communication of Business Proposals'; 'Market Segmentation'; and 'The Marketing Process'.

In order to develop teamworking skills, the students are set weekly tasks to complete within their groups, for delivery to the class for feedback by the module convenor and the wider cohort at subsequent sessions. These include use of recognised management and entrepreneurial tools such as the Strategyzer Business Model Canvas (Figure 2), small group presentations, elevator pitches, and role playing (in the context of professional roles within a company).

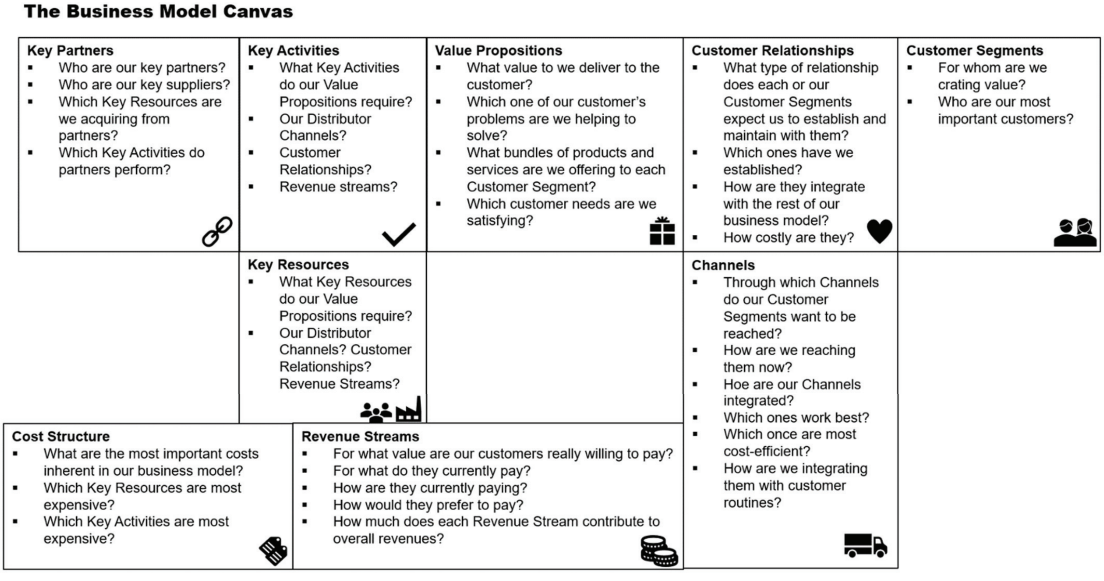

Figure 2. The Business Model Canvas, modified (original available from strategyzer.com, accessed on 31 March 2021).

Students are assessed 100% by coursework which constitutes a business plan of ca. 4000 words (worth 60% of the module mark) detailing the group's idea or proposition and an opportunity to formally pitch the business idea via a presentation or video (worth 40% of the module mark) to an 'expert panel'. The panel consists of the module convenor, successful industrialists, and other academics (including from international universities), which comprises some of the guest speakers (to represent continuity in the module proceedings), and is concluded with a Question & Answer session which is used to further enhance learning, providing students with the opportunity to respond to questions, pro-

vide verbal clarifications, and to gain first-hand (constructive) feedback regarding their business proposition.

The module has been successfully delivered for several years with consistent positive student feedback, such that the basis of the module has been replicated for students in the Department of Biological and Life Sciences at this same university and for engineering students at a partner institution in China.

2.2. Pivoting to ERT

In the course of pivoting to ERT, the module convenor had very little time to consider either the wider implications for online teaching and learning or any opportunities being made available from the university for online delivery, a scenario faced by many educators globally [38]. Rather, the convenor had to find solutions that would allow the continuation of delivery and the ability to progress and conclude the academic year. Transitioning from a module that historically has benefitted from the intensive, face-to-face workshop-style environment where visual and emotional behavioural cues help to engender team cohesiveness and relationship development, to one conducted entirely online, often with cameras switched off (in the case of the students) proved to be the biggest barrier to address. Added to this, despite being online, the geographical location of students played a key consideration, particularly as the majority of international students within the cohort felt it necessary to return to the support of family environments in their home countries, due to the longer-term uncertainty of the pandemic situation. As such, two 'international groups' were established to take account of time zones—one in South East Asia (primarily GMT+7) and one in Eastern Europe (primarily GMT+2), with the remainder of students being located in the UK and Western Europe (GMT+1). Weekly sessions were therefore scheduled for 10am start (within core hours for the majority of the class based in the UK), but within a reasonable time difference for access by others, particularly in South East Asia who essentially had to phase shift their working pattern to a later part of the day (also accounting for other university work)—additionally, these international groups could then set their own schedules for working collectively (e.g., preparing for the weekly tasks) at a time of day more conducive to their location. Feedback received was positive, emphasising that inclusion of all students had been considered, despite the difficulties of the (rapidly changing) situation faced. More generally, there was acceptance from within the cohort that there would be much wider implications affecting educational provision in the longer-term, including the likelihood of online learning being here to stay, a position felt not just at Lancaster University, but by undergraduate students more generally [38].

Guest speakers embraced the opportunity to participate virtually, primarily through synchronous delivery (in order to engage in real-time question and answers sessions—a source of rich learning from the 'experts'), but also through asynchronous content, made available from the module's dedicated virtual learning environment (VLE) site. All sessions were recorded and made available afterwards on the VLE, to allow the students to access this at a later time to reflect on the content delivered, recap on feedback provided from the weekly tasks (an opportunity never provided previously when the module is delivered real-time in-class) and to fully understand the task set for the week ahead (where ambiguity may exist). From a module convenor perspective, it was positive to note the students' use of the main Microsoft Teams group for the weekly sessions whilst simultaneously communicating with group peers within their private channels, as they discussed and established ways forward to tackle for example, the weekly tasks set, and to then confirm any misunderstandings within the main group before proceeding. Such interaction and engagement is not possible within the classroom environment, where team members can be spread throughout the room, relying on post-session discussions to clarify learning and discussing how they will proceed with the next task at hand.

Of particular note was the opportunity to capitalise on the situation of operating online through invitation of an international guest speaker, and senior business person who would not ordinarily have the time to dedicate for an in-person visit to the university,

but were more than willing to join a short session online with the cohort. Being able to facilitate such opportunities brings significant added value to the learning experience of the students.

3. Methodology

A case study approach is an effective way of capturing the complexity of learning and teaching and the contexts and communities surrounding them [39], with particular regard in this situation to context; this approach exhibits close alignment with case study because of it being a bounded unit; it is located within a community, involves interactions and relationships between the case and the wider world, focuses on collecting rich data over a short period of time, and uses a variety of data collection tools [39]. Data legitimacy is provided by reporting on the perspectives of both teacher and student and using different data collection methods: formative student feedback, summative student feedback, reflection, and a thematic focus group. This triangulation helps to reinforce the quality of data collected [39], providing a thorough picture of ERT in the context of entrepreneurship education for undergraduate engineering students.

3.1. Formative and Summative Student Feedback and Feedback to Students

Formative student feedback was collected throughout the module via informal student-teacher interactions with the module convenor, mostly achieved through the Microsoft Teams platform. Immediate feedback is provided to the student groups (from the module convenor and student peers (engendering peer-to-peer learning [40])) following the delivery of weekly tasks set, but also on an ongoing basis (from the module convenor) through the use of channels (workspaces) within the Microsoft Teams platform, with each individual group operating within their own channel. Summative student feedback was captured by the end of module feedback questionnaire as required by standard university quality processes. Of the total class size (177), 38 responses were received, providing a 21.47% response rate. The sections of the evaluation which include written text were then analysed and coded based on the themes used in the focus group.

3.2. Reflection from In-Module Student Engagement

The opportunity to engage more closely with the student cohort (assigned to 15 independent groups of 10–12 students per group) using the online MS Teams platform, and in particular the digital trail that was created as each week passed, presented the module convenor with the chance to reflect, adapt, and reconfigure the module programme to ensure best advantage for all module participants (teaching staff, guest lecturers and students).

> *"Group involvement over Teams was great and responsiveness and comments from [Module Convenor] were extremely helpful".*

> *"I enjoyed coming up with a product and exploring the best way to implement it in a group setting as it allowed all decisions to be discussed".*

Reflecting on Kolb's Learning Cycle [41] directly in relation to online teaching delivery and the functionality of online platforms enabled the possibility to review, in real-time, students' engagement within sessions (which could still be viewed at a later date); this enabled appreciating the experience (Stage 1: Concrete Experience) of the students during these sessions, for example, as they developed their understanding of theoretical and practical material presented. Within the weekly tasks, students were able to reflect this in their own work, for example by taking best-practice approaches to completing tasks (presentations, elevator pitches, etc.; Stage 2: Reflective Observation). Through subsequent individual group workshops and full-cohort discussion sessions, students were able to discuss the likely implementation of this best practice incrementally into subsequent weeks' activities (Stage 3: Abstract Conceptualisation). This was evidenced and realised through the formal weekly deliverables where students would subsequently apply this knowledge (Stage 4: Active Experimentation) following peer discussion within groups, supporting

each other to the best effect. Ultimately, the benefits of such learning and reflection, across the range of engineering disciplines involved, supported the end-of-module assessment materials, where the formation of business plans and presentations/pitches were perfected based on this cyclic approach.

> *"Getting to work with engineering students from different disciplines highlighted our different ways of thinking and problem solving, and made for some great teamwork and collaboration".*

Capitalising on using digital media more effectively, the module convenor was able to adopt Kolb's Learning Cycle and experiment with redefining aspects of the final assessment (whilst being cognisant of the need to adhere to the existing module learning outcomes). Students, having used video for aspects of their weekly deliverables, were therefore presented with the opportunity to create a 'multimedia promotional video' for their business proposition, as an alternative to a formal PowerPoint presentation.

3.3. Thematic Focus Group

A group of five students, two of whom were course representatives (participating on behalf of their respective engineering programmes) engaged in a post-module focus group to discuss their experiences of pivoting to online learning, generally in relation to the wider engineering curriculum, but specifically in relation to this entrepreneurially focussed module. This focus group aimed to elicit deeper feedback from students than those in the previous formative and summative student mechanisms. The focus group as a means of qualitative research has several strengths, including a cascading effect of discourse amongst participants and efficiencies of scale derived by interacting with several individuals simultaneously and serving as a mini-interaction laboratory [42]. Group interviewing can be particularly helpful when participants have been working together for some time with a common purpose [43], such as shared educational experiences. An interview schedule was devised which sought to extract feedback, congruent to the aims of the study. It was structured firstly with introductory remarks that included an emphasis on making improvements for the following academic year, which helped to create rapport and a sense that participants' input could have a lasting effect. The four principal sections devised for discussion were: Pivoting and Summer Term; Interaction/Software; Technology in the context of institutional platforms; and Outcomes. Table 1 provides the questions that were asked in each section.

It was conducted on Microsoft Teams in late July 2020 lasting approximately 1 h 40 min and led by the authors, recorded, and transcribed. The transcription was imported into NVivo 12 from where qualitative data analysis was undertaken. Firstly, to explore the data superficially, in-software visualisation tools were created such as word-clouds and hierarchy charts. Following this and using an inductive approach method, codes were generated where content emerged from the transcription; this resulted in the creation and use of 28 separate (grandparent, parent, and child) codes, which were referenced 175 times. Given the small number of participants, no case classifications (i.e., personal characteristics) were assigned. Pseudonyms are used to protect anonymity of those students participating. Using these four methods (formative student feedback, summative student feedback, reflection, and a thematic focus group) provided insights with those that contain multiple instances as forming the most pertinent points and hence the basis of our reported results.

This study has used student feedback via formative, summative, and focus group methods, on one course from a single institution, and as such the results may be relatively limited in terms of generalisability. The inductive nature of the work is intended to describe the emergent issues that have come from ERT early in the pandemic and as such, the reliability of the data may be limited.

Table 1. Breakdown of the questions (by section) used in the thematic focus group.

Pivoting and Summer Term
• Thinking back to the Easter vacation time, are you able to recall any expectations you had about teaching during Summer term? ○ Was there anything you felt anxious/apprehensive about? ○ Was there anything you felt excited about? • Describe your own experiences of learning during Summer term. • What were the biggest challenges for you in terms of learning during Summer term?
Interaction/Software
• Thinking now about ENGR205 in Summer term, broadly, how would you describe your learning experience? Was it generally positive/negative/indifferent? Why? • What were the biggest challenges for you specifically in terms of this module? • Teamwork is a large part of this module. Could you describe your experiences of working with your teammates? ○ Did you use any platforms not prescribed by the lecturer (e.g., Messenger, WhatsApp, E-mail etc)? ○ Did you 'meet' your team using video/call technology, e.g., MS Teams, Zoom, Skype, WhatsApp etc? ▪ (i) If so, how many times? ▪ (ii) Did the whole group attend? • Roughly how much of the interaction with your team as a %age was conducted using MS Teams (if for example, you used no other platform to interact, this would be 100%)?
Technology in the Context of Institutional Platforms
• How often did you access ENGR205 Moodle space during the course of the module (daily, every few days, weekly, every other week, monthly, once or twice, never)? • What were the main reasons you accessed Moodle? ○ e.g., to access lecture recordings, access resources. • Had any of you used MS Teams before the start of Summer term? ○ What was your primary reason for using MS Teams before this point (learning, communicating, collaborating, etc)? • Could you describe your experiences of using MS Teams for learning? • How happy would you be to use MS Teams again in other modules as part of your degree? ○ What were the largest difficulties for you using MS Teams? • Do you have any suggestions on how the use of MS Teams could be improved? • Do you have any suggestions on how the use of Moodle could be improved?
Outcomes
• Describe any benefits of learning in this (remote/distanced) way, over conventional teaching methods? • Thinking about delivery rather content, was there anything that surprised you or was unexpected? • We may have covered some of this already but . . . are there any other recommendations you would like to give to teaching staff that would help students and the learning experience?
Students were then provided with the opportunity to make any other comments or general feedback.

4. Results

4.1. Learning and Teaching Delivery

Evidence of submitted work shows that learning outcomes were achieved with a recognition that the speed of pivoting to ERT was no easy accomplishment of the module convenor. Interestingly, rather than appearing anxious about this mode of delivery, students from the focus group reported a sense of excitement about the novel ways of learning, this being the first module taught to the year group entirely online since the move to ERT some weeks earlier. There appeared to be an openness to new learning brought about by the situation. This was somewhat quelled by uncertainty, especially of exams, which at Lancaster University typically take place for undergraduates at the start of summer term (April). As the first lockdown in the UK had begun, on the one hand there was anticipation of new ways of learning, yet on the other hand, students demanded certainty in what they might expect for the remainder of the academic year.

Students reported feeling more relaxed as a consequence of being in a familiar home environment rather than a lecture theatre. This had other benefits for individuals who

had quietness and for example were able to utilise a desk to make notes and access to multiple dedicated computer hardware, all of which contributed to a conducive learning environment. However, this was not the case for all and one focus group participant did not have enough desk space at home for themselves and their siblings, meaning that this student completed all of their work on their bed. In the case of the former student, being on-campus would have presented a more favourable study environment.

There was no evidence in any of the student feedback that learning virtually was inferior to face-to-face teaching for this module. Students were actually keen to point out that lecture delivery improved in some ways, through the use of asynchronous recordings, where they could pause at any point to take notes, carry out online searches, or replay sections that were of particular interest or clarification was sought. This was highlighted when a focus group participant fed back that teaching staff during synchronous sessions were not able to recognise confused looks on the faces of students and had not prepared any ways of obtaining feedback or checking understanding in the course of delivery of another module. This was magnified when it was felt teaching staff had actually sped-up in terms of delivering content online, synchronously. There was support for synchronous sessions which was mostly to enable dialogue, by teaching staff responding to questions and providing structure to students' working weeks and working days.

4.2. Teamwork and Group Dynamics

It is clear that students valued group work with consistent positive comments from summative, formative, and focus group feedback. Students appeared to meet regularly in their groups (channels established in Microsoft Teams), multiple times weekly with some variance, and recognised that frequency changed when workload dictated. The often-cited frustration of students that are placed into teams that have members who contribute unequally unsurprisingly does not abate with doing this virtually. This was highlighted by 'David' in the focus group who commented on his observations of levels of contribution from different members:

> *"I think there's some people who put more effort into the peer review than the report".*

The point of parity was given further consideration by 'Baris' who reflected on this compared to future professional working environments:

> *"I think it is a sad reality that in the workplace some people will not pull the same weight as others".*

Whilst it might be discerned there is little difference to what is a ubiquitous issue amongst teams in virtually all types of environment, some aspects of engagement, delegation, and motivation appear to differ. The issue of presence was raised as a recurring point, in that individuals could appear to be present by joining a meeting yet contribute very little. Whilst a parallel can be drawn to the physical world of people who arrive at meetings and contribute little, the issue was felt to be more pronounced in the virtual context as individuals can join with extreme ease and could be doing other tasks at the same time. This is essentially epitomised by the almost universal decision of students to turn off their camera function, which has communication benefits of being able to see and respond to body language and non-verbal cues.

Having identified issues of performance amongst individuals, team leaders reported different experiences of addressing this, compared to doing it in-person. Some found it harder to do online and would have preferred to have dealt with underperformers in-person. Other people found it easier to address online (for instance by direct written communication) but interestingly found that the effect of this was less. In other words, although confronting someone face-to-face was harder, the effect of this was perceived to be greater. 'Raymond', a team leader captured the point in the following way:

> *"Whilst it's easy to confront people about that, it's a lot easier for them to just sort of ignore you."*

4.3. Technology and Online Platforms

There was extremely widespread support for the use of Microsoft Teams as the preferred platform for engaging with formal content through synchronous sessions and asynchronous collaboration, with some students even reporting enjoying using it. This was used as the primary means of collaboration in the majority of teams that were represented in the focus group and positive feedback included ease of use, file sharing ability, updates from the developer, and use of the chat function. The chat function received particular praise as a way of asking questions during synchronous sessions that the same individual would not have done so, if in a lecture theatre or workshop environment. The ability to 'like' comments or questions was also seen as a particularly helpful means of agreeing with classmates, something that is not readily achievable in large-class situations. Students appeared to be uniformly in favour of Microsoft Teams as a platform for supporting learning by engaging with teaching staff and fellow students in a formal sense.

However, Microsoft Teams did not provide students with a social space where they could converse and "be friends" away from the more formalised platform used by the university and overseen by teaching staff. Students quite rightly placed a high value on this rapport-building aspect to their team development, which might include the side-line conversations that occur, further enriching interaction between group members. It became evident through the focus group that in order to achieve this alternative manner of connecting with fellow students, the Facebook Messenger platform was also used consistently and often comprehensively by some groups. Students felt that this was a place where they could put faces to names and ergo by inference, personalities to faces. It was also seen as a more casual channel in which punctuation, grammar, and spelling was less important than in using Microsoft Teams, which could be viewed at any time by university staff.

Other platforms which were referenced by students in helping to co-ordinate time and make decisions was Doodle Poll and Qualtrics, although it should be noted that the polls function in Facebook Messenger was cited as being used too. Google Drive was used to work collaboratively on documents where real time edits can be made by multiple users. Most student teams used Microsoft Teams for meetings. Discord was used to meet by one team represented in the focus group, but with generally negative feedback due to lack of features compared to other platforms and the team appeared to regret using it. No mention was made of other platforms such as WhatsApp, Skype, or Zoom. Use of the university's virtual learning environment (VLE), Moodle, was generally low with students reporting accessing it mainly to download module specific documents or obtain information (such as recorded sessions and the lecture slides) as well as upload the completed assessment materials.

5. Discussion, Conclusions, and Implications

It is evident from the formative feedback, supported by the focus group that students required certainty and clarity, which in times of unpredictable crisis can be difficult for university management and academic teaching staff to provide. This was mainly focused towards exams, and before announcements were made, it proved to be a point of concern and anxiety amongst the student demographic. The need for universities to not just communicate but take decisions early remains paramount to maintain student satisfaction.

Flexibility has long been seen as a contributing factor to students' decisions historically to opt for distance learning programmes [44], as this presents the beneficial opportunity of balancing study with other commitments. These advantages are only partially applicable when considering the forced nature of students to return to family, parental, or guardian homes where learning environments may have very stark and striking differences. An example of this is seen even in the small focus group which formed part of this study in which 'Raymond' had his own room with various computer hardware atop ample desk space whilst 'Julie' was working on her bed because her siblings were using the only available desk space within the family home. The authors present this as a necessary

reminder that teaching staff need to have an appreciation of the likely differences in home learning environments, even if they are not intimately aware of each learner's personal circumstances.

As reported elsewhere [45], there are important access considerations when delivering material online, most patently that learners have internet access. Indeed, recent calls have been made by individuals such as Sir Tim Berners-Lee (who invented the World Wide Web) to make access to internet connectivity a universal right [46]. Computer infrastructure is an important pre-cursor to achieving such equity yet the idiosyncrasy presented by individual's personal circumstances need to be both recognised and where practicable, accommodated. Universities may not have the means to alter the learning environment but teaching staff should recognise that there are likely to be considerable differences amongst any given demographic. This may have profound impacts for issues such as quality of learning and knowledge retention.

Students need support in making group work as effective as possible [47], regardless of whether this is in-person or virtual. From the results presented, it appears this is an issue that requires teaching staff to reframe how teams are supported to be nuanced to the virtual world, if this is how the team will function. This requires specific guidance and scaffolding on team formation and performance, such as that which has been done in organisational development [48], as well as providing the infrastructure for teams to achieve optimally in virtual workspaces. Part of this is to consider how a climate of trust can build and sustain virtual teams [49]. A further recommendation for online group work informed by the results is, where practicable to do so, to use smaller teams, in the region of six instead of twelve participants. Such preparations are likely to have a side effect of preparing students to deal with a future professional working world where physical collaboration is less likely and where global virtual teams are more commonplace [50].

The demand for graduates to possess work-ready, transferable skills has increased by employers [24] and the pivotal role of teamwork within this is recognised universally. Our research shows that teamwork has presented different characteristics online, relative to face-to-face. It should be emphasised that the key feature here is not a reduction in attainment of learning outcomes but that there are features which are simply different. The most commonly reported was the issue of presence amongst team members, the significance of which is supported by previous research in online distance education courses [51]. Our own work shows the importance of students being present in team-based endeavours, which in very practical terms may include ensuring that they are actively contributing, turning cameras on, and leaving footprints or evidence of engaging within learning platforms. There are clear differences between temporary and ongoing distributed teams [52] and identified antecedents to conflict that are unique to distributed teams [53]. Being diligent, polite, and respectful members of a team in a distance learning environment will prepare students for when these very same qualities are required in a future online working environment.

From the research undertaken here, there are a number of implications for university teachers, educational institutions, and students which may be posited. For teachers of large undergraduate class courses, it is paramount that there is acknowledgement and a degree of sympathy with the variety of home environments that their students will be in. Some of these may be less conducive than traditional university studying environments and whilst changing those is unachievable, recognising and accommodating this should remain foremost in teacher's approaches. This includes thorough planning along with compassion [16], and instructor guidance and assistance, which it has been shown has a significant impact on students completing learning tasks [52]. Our own research suggests that instructors should consider the speed of their vocal delivery, especially in asynchronous content and by inviting feedback early-on from students during their course, and modify as appropriate.

For institutions, providing the software infrastructure to support learning in as consistent a way as possible is important. From our research, platforms such as MS Teams are

widely advocated by students and teaching staff, however any formal system such as this is not preferred for students to interact socially. The importance of learners' social context has been shown previously to be ignored by many educators [51], yet is a vital aspect to online learning. Teaching staff should recognise the social needs of students and instead of attempting to provide for this through formal methods, signpost students to initiate and take part in this outside of formal constructs. We found that social media platforms were reported by students as providing this essential connection and networks with their fellow students where they could exist as friends, not just as fellow students.

One of the potentially gravest and as yet unknown consequences from COVID-19 is the longer-term effects that have come from interrupted education, isolation, and grieving (at the loss of family and/or friends) or a combination of these experiences. As reported earlier, research [15] has been undertaken to consider the psychological impacts on university students, referred to as an increasingly vulnerable population. Whilst there are factors that contribute to higher levels of psychological impact that are out of the control of individuals (such as family income, race, and knowing someone infected with COVID-19), there are factors which reduce this impact such as spending at least two hours outside or less than eight hours on electronic screens [15]. Universities need to urgently develop intervention and prevention strategies to address psychological impacts that will affect long-term mental health [54].

We have reported a sense of excitement from the students initially about moving to a new way of learning, essentially bought about by the novelty of doing things differently. We believe this constitutes a "honeymoon" period and that the relative euphoria rapidly fades. Our experiences in this context show that some surveyed students have responded in an adaptable way to the emerging environment, closely resonating with themes of resilience and determination. Students that believe academic qualities can be taught (rather than being fixed) show higher achievement across challenging social and academic environments [55]. Furthermore, findings have demonstrated the positive correlation between determination and a range of academic performance indicators, underpinning the role that self-efficacy has in achieving such outcomes [56]. Linked to our own research, this supports the case for formal resilience training, as has been successfully used in other professional discipline education programmes [57] to become a feature of skills development in engineering courses. Such activity would be well-suited to entrepreneurship education given the significance it plays in company start-up success [58] and emerging business resilience frameworks for start-ups [59].

For students, it is clear from the work undertaken here and that of others [16] places a high value on structure and time management. Identifying daily, weekly, and termly routines that fit idiosyncratically into one's own personal circumstances is a fundamental step to gaining the most from learning at a distance. This forces students to consider their own self-discipline and transferable skills, such as time management, in a way that beforehand, was in part achieved for them, for instance with timetabled lectures and laboratory sessions. Asynchronous content inherently places responsibility on the student to actively engage with the material and having the supporting cognitive frameworks will help considerably. In a practical sense, this may mean developing and persevering with a timetable, regular study group sessions with peers, and the use of planning systems such as Gantt charts and work breakdown structures. Fundamentally, the benefits of sound planning, establishing a routine that works for individual circumstances, and actively managing time will most likely result in more positive learning.

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Article

Face-to-Face vs. E-Learning Models in the COVID-19 Era: Survey Research in a Spanish University

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Abstract: This study shows the results of an autobiographical questionnaire of Spanish university students regarding two different educational models caused by the COVID-19 pandemic: face-to-face and e-learning. The aim is to discover their perceptions and opinions about their experiences during the learning process and what they have experienced during this global emergency and period of home confinement. The sample is made up of 100 students from the Primary Education Degree programme and the research was carried out through a qualitative study of the questionnaire. The results, divided into categories of each educational model, show the interpretation that the students make of the current reality and their own learning process. The most important aspect of the face-to-face learning model, according to 75% of the students, is direct communication with the teacher, and for 88% of them this model was effective. For the e-learning model, the flexible schedule, the economic savings and explanatory videos are the relevant ideas that the students express, with 68% stating that it was an effective model. The main conclusion is that the students prefer to continue with the face-to-face learning process (49%) rather than online teaching (7%) or, failing that, mixed or blended learning (44%), where the theoretical classes could be online and the practical classes could be face-to-face.

Keywords: COVID-19; education; e-learning; face-to-face learning; perceptions

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1. Introduction

The year 2020 will be remembered in the history of humanity as the year of the global pandemic caused by COVID-19. The health alarm made what we had until then known as "normal" cease to be so in all areas of our lives. In education, the simple daily act of going to class became "staying at home" in front of a computer, with consequent stress and technological fatigue. This situation changed our ways of perceiving and seeing education, of how to teach, how to learn and how to evaluate the acquisition of competences and abilities by students.

The purpose of our qualitative research is precisely to learn how the university students see our current form of education [1]. We aim to find out their perceptions and opinions about their experiences during the learning process, what they value from face-to-face education and distance education and what they have experienced since the state of alarm was decreed in Spain on 14 March 2020 [2].

There have been numerous ideas, proposals, press articles and research on COVID-19 and its impact on education [3], and how the next course (or the next school year) should be faced. Of all the studies, we should highlight the theories presented by Trujillo et al. [4] and Diez-Gutierrez and Gajardo-Espinoza [5]. The latter reveal the digital, educational and social gap that occurred during confinement, as well as the educational policies adopted in Spain, and they also carry out an investigation by surveying family units throughout Spain. This research aims to describe the view that families have on how to manage education and school assessment in times of COVID-19. Likewise, Trujillo et al. [4] carried out a study of teachers, families and students in order to provide key conclusions to help understand the

position of the educational community in the face of the state of alarm. They also offer an action plan and some recommendations for the next school year in primary and secondary education. They show that students are not happy with the level of teacher attention towards them and show frustration and dissatisfaction with the excess of submitted work required. In the case of university students, Demuyakor [6], Muthuprasad et al. [7] and Nguyen, Pham and Nguyen [8] analyse the perceptions of students about their training during the pandemic. For example, Demuyakor [6] concludes that learning success requires good teacher–student interaction, and that it is essential to notice that technology cannot replace the teaching work of a teacher.

The main aim of the present study is to identify the perceptions of university students who have to deal with two different educational models of teaching that they have been confronted with due to the global pandemic, in order to establish guidelines or design an appropriate teaching methodology plan related to teaching and learning practices to be used in the next school year. It is important to discover the opinions and concerns of the students, to establish some guidelines based on them and on teachers' experiences, and to find the teaching model that best suits the needs of students, so that the teaching/learning process can be effective. It is therefore a question of thinking about the teaching and learning process, verifying how lockdown has influenced this process, and evaluating whether the resources have been useful for student learning. Finally, the results of this research study will be used to improve teaching practice and professional action in future educational settings.

The educational models of teaching and learning experienced by university students within the same semester and subject can be identified with the face-to-face learning model and with the e-learning model [9–12]. Face-to-face learning, which we will call F2FL, takes place completely face-to-face in the classroom, both for theoretical lessons and practical classes, combining pedagogical practice with others carried out online on the subject's Moodle platform [12,13], such as: communication with the teacher (notices, chats, forums or emails), sharing documentation, submission of students' tasks and PowerPoint presentations using a projector in face-to-face classes. The latter educational model, e-learning, which we will call EL, corresponds to a totally online education training supported by ICT, without any physical presence in the classroom. The theoretical and practical lessons as well as the meetings are carried out synchronously using each subject's Moodle platform, along with Google Meet or YouTube, or asynchronously with explanatory videos of the subject content or the practice in question. In our case, the EL model is a combination of synchronous and asynchronous lessons and/or tasks [12]. Students had to make continuous use of their computers, tablets or mobiles to connect to the internet and follow their teaching-learning process from home.

The F2FL model was experienced by the students from 10 February to 13 March 2020; and the EL model was tested between 16 March and 29 May 2020, the day classes ended and the exam period began, which were also conducted online. We want to emphasize that the subjects are prepared and planned for an F2FL educational model, i.e., for being taught in the classroom, and not for being taught online. Over only one weekend, the teachers and the students had to make a huge effort to adapt themselves to the new situation (home confinement) and to the EL model. With this, we would like to make clear that the change in educational model was not gradual, but was very fast and could not take full advantage of the positive aspects of e-learning teaching.

2. Background

As mentioned in the previous section, this paper presents the results of an autobiographical questionnaire of Spanish university students regarding two different educational models brought about by the COVID-19 pandemic: face-to-face and e-learning.

Nowadays, the F2FL model is enriched with the use of the internet in the sense that teachers and students have class in traditional timetables and classrooms, but also use the virtual platform or classroom, where the teacher can upload diverse information needed for

teaching, and which is a learning support for the student at home. The virtual classroom is conceived as an information space containing the subject's programme, schedule, different documents for learning and practical classes, meetings, etcetera [10]. This represents the basic educational model in the use of virtual classes, planning it as an appendix to the traditional F2FL model, in which the teachers do not change the activities, the type of communication and the teaching methodology. In short, the teacher continues with the usual methodology, but supported with a technological resource [10].

With respect to e-learning, first of all, Rosenberg [9] defines learning as the process by which people acquire new skills or knowledge for the purpose of enhancing their performance; and he also says that there is a migration of information to the online environment, which can be updated continuously. Although face-to-face learning continues to play an important role, more people are demanding access to learning anytime and anywhere. Rosenberg defines e-learning as a networked phenomenon allowing for instant revisions and distribution of information and tools to improve learning. E-learning is powerful when both training and knowledge management are integrated, but even more powerful when integrated with classroom training in a learning architecture, which is the design, sequencing, and integration of all electronic and non-electronic components of learning. Area and Adell [10] state that the main characteristic of e-learning is that it is a training process that occurs totally or in part through a virtual environment where both the teacher–student interaction takes place as well as the students' activities with the learning materials. They show the benefits of e-learning, and some of them are the following, as also cited by Rosenberg [9]:

1. Extend and facilitate access to learning for groups and/or individuals who cannot access the face-to-face modality.
2. Increase the autonomy and responsibility of the student in their own learning process.
3. Flexibility in educational times and places.
4. Access to many resources and data offered by the teacher at any time and any place.

The blended learning (BL) educational model falls midway between EL and F2FL. It is a combined model of teaching with presence in the physical classroom and in the virtual class [10,14]. The virtual class is not only a source of support, but is a place where the teacher develops various actions for student learning. This new BL model is an innovation with respect to the F2FL model, creating new ways of communication and teacher–student interactions and in the teaching/learning process. Chandra and Fisher [15] conducted a study of students' perceptions of a blended-learning environment, where they obtained positive perceptions, such as: accessibility and being able to rewatch as many times as they liked, the environment promoted autonomy of learning, it enabled students to work at their own pace, and sustained interest in the subject. However, on the negative side, they reported that many students preferred the option of asking the teacher in a face-to-face environment, where their question could be answered in that moment, rather than by email, which could be delayed or misunderstood. Nonetheless, overall, the BL model has the positive aspects of the other two models, being a mixed model of both. By way of example, in the use of the BL model, Piñero and Costado [16] present the results obtained with co-designed activities focused on the development of competences linked to the development of geometric knowledge in student teachers. They conclude that the implemented experience in BL learning contributed to generating more complex, rich and varied geometric problems, preserving the objectives of content and procedures.

There have also been previous studies on the opinions of students in two different learning situations, showing their preferences and dislikes [17–20]. All of them show similar conclusions or focus their attention on the same ideas, talking about the relationship of the student with the teacher and other classmates, manipulative materials, bad connectivity or problems with the internet or lack of technological devices at students' homes. Altunay [17] and Gunes [19] conclude that the majority of students do not want to receive instruction through online distance education methods, while Altunay [17], specifically, shows that the lack of autonomy in distance learning is conditioned by how students were taught

without being autonomous in secondary education. In their study, Noviana, Sukardi and Suryanti [21] show that the learning process is affected by different aspects, such as gender, age and school type (urban or rural). They conclude that female students were better than their male counterparts because they are more motivated and have better abilities in time management. They also state that the eighteen-year-olds suffer a decrease in cognitive function in associative memory, which affects learning ability, and that the learning process is affected by the availability of access to technology, while the lack of resources and infrastructure played an important role.

Finally, concerning the educational models, there is the study by Johnson et al. [22]. Their results revealed that their students held more positive perceptions about the instructor and the whole course in the face-to-face compared to the online model, although there was no difference in the measure of learning. They highlight as quality characteristics of the F2FL model: the students' ability to maintain a dialogue with the instructor and others, and the opportunity to receive multiple and diverse examples and illustrations from the instructor, which were of poor quality in the online environment. Moreover, in this research study, they emphasize that students in the F2FL model can join together more easily to discuss class projects, work out any differences of opinion, and build social relationships, in contrast to the EL model. It is therefore reasonable to assume that the relationship between students and interaction with the instructor are among the most important for students.

3. Methodology

To achieve our aim, we chose a descriptive qualitative method [23] where the testimonies of the students are collected through a qualitative questionnaire [24] of open questions structured in three sections to discover the perceptions and opinions of the students regarding each of the educational models presented above, and which they prefer to follow in their training. In addition, the questionnaire had a fourth quantitative section to assess the resources used during the two educational models of teaching. The students had to rate from 5 to 1 each of the resources set out in the questionnaire, with a 5 being valued as "very useful" and a 1 as "not very useful". The students were even given the option of not answering with the option: "do not know/no answer" (NK/NA). In the results section, there is a specific sub-section where the students' assessments are shown.

The initial theoretical position of this qualitative research is the symbolic interactionism of Grounded Theory [25]. It explains that the central research starting point for qualitative research consists of the different meanings that individuals give to their own experiences or events. The data analysis involves carrying out a survey, codifying the information into categories and comparing the information obtained. This theory allows one to give an explanation to the relationships between two or more categories of the same reality. It is thus a constant comparative methodology of data analysis and constitutes a set of conceptual hypotheses about the reality studied [26], whereby concepts and hypotheses are formulated throughout the research itself. The researcher (member of teaching staff) fragments and segments the data contained in the text, trying to list a series of emerging categories (open coding). This entails classifying the expressions contained in the text to assign concepts. The most interesting are selected from all the categories to make a deeper analysis, enriching them with more passages from the text (axial coding), to finally obtain a central category (selected coding) that includes the other categories [25].

Our premise is to analyse the interpretation that a group of students makes of the reality that they had to live through during the pandemic. For this reason, we analyse their perceptions, opinions and experiences of the two educational models (F2FL and EL) that they experienced in the same semester and subject, and then we compare them. From the students' own words, as we will see in the results section, a third, preferred educational model can be extracted, as can the subjectivity aspect, that is, aspects related to their emotions and feelings.

The survey consisted of three sections of open questions in the form of an autobiographical questionnaire for students to express their own opinions about the two educa-

tional models. In qualitative research, the narrative biographical approach comprises data collection and analysis methodology, and a way of building knowledge in educational and social research [27]. Autobiography allows the researcher to gain proximity to students and their reality. The sections of the autobiographical questionnaire were the following:

1. Section 1 consists of four open questions to learn the opinion of the students about the F2FL model, taking into account their individual experience and to find out whether they were able to argue positive and negative aspects of the model, to give some recommendations for improving such a model for the next course, as well as assessing whether it had been effective or not in their own personal cases.
2. Section 2 contains the same questions as in Section 1, to find out the students' perceptions of the EL model.
3. Section 3 has two open questions, asking about what educational model they would like to continue their training with at the university, and their concerns or other aspects that the learners would like to express about the situation generated by COVID-19 and had not expressed previously in the first two sections.

The participants in this study were Cádiz university students, from the Primary Education Degree of the Faculty of Education Sciences. The sample is made up of two sub-samples, since students from two different subjects in the area of mathematics have participated. These two sub-samples were chosen because the authors of the paper were the professors of these students. The total number of enrolled students was 140, and 100 of them participated in the survey, i.e., a response rate of 71.4%. Specifically, 47 of the 100 participants were enrolled in the subject of Mathematical Knowledge I, and 53 in the subject of Didactics of Mathematics I. Of the 100 students who responded to the survey, 72 were women and 28 men, with an age range between 18 and 20 years old for the vast majority.

The survey was prepared by teachers (authors of the paper) in April 2020, using an anonymous Google form and it was made available to students in May 2020, so that they could answer it during that month. In the month of June, the teaching staff proceeded to analyse the students' responses. For this reason and for this analysis, the responses in each of the sections that were part of the data collection instrument were read repeatedly. The first step of the analysis was the extraction and collection of fragments of the original autobiographical texts that provided relevant information about the educational models. After this, the data classification began with the determination of categories that come from the collected material, looking for conceptions or ways of thinking shared by the interviewees.

4. Results

The analysis of the data collection instrument, that is, of the survey, went through the following processes. There was a first extraction of relevant fragments from the original autobiographical texts from the questionnaire, where they give information on the two educational models. These fragments were subsequently analysed by the authors of the paper (teaching staff) to be codified and to identify each category. These categories are the conceptions and ways of thinking shared by the interviewees (students) of the same reality. In our case, this reality was home confinement and the change in educational model, from F2FL to EL. For each model, the extracted categories are each one of the positive and negative points or ideas. We must focus on what the interviewee says and not how they say it, and we have to compare what the interviewees say.

From the original fragments, we can extract the characteristics of a third educational model and other categories related to the students' emotions. The subjectivity section has been added to our study, because as the students' responses were read, it was seen that they emphasized expressing their feelings and emotions, as if to reflect the situation of negativity they were experiencing.

Below, in different sub-sections, the common responses most repeated by the students for each of the educational models are summarized. At the same time, specific fragments of the students themselves are shown that reveal the opinions summarized in the different categories. The first subsection shows the results for the F2FL model, the second subsection

gives the results with respect to the EL model, and the third subsection shows which educational model is preferred by the students for the continuation of their training. Finally, in the fourth subsection, we reveal the opinions and emotions caused by the pandemic situation (subjectivity).

The results are organized into different categories that arise from the analysis of the students' autobiographical texts. These are called relevant fragments, which are those parts of the original texts that give information about the categories to be studied [28,29]. A selective coding is then carried out to group the relevant texts according to the categories analysed, and we look for ways of thinking that are shared by the students, and the percentages of each category are obtained, that is, how many students share that thought or opinion for each category. The most relevant categories of each educational model and its corresponding percentage of students supporting it are shown in Table 1.

Table 1. Categories and percentages of students that expressed some relevant phrases in favour of each category of each educative model.

Model	Category	Percentage (%)
Face-to-face learning model	Direct communication with the teacher	75
	Direct communication with other students and the possibility of working in a group	55
	Use of physical materials	42
	Explanation, questions and doubts	51
	Effectiveness	88
Electronic learning model	Flexible schedule	44
	Economic savings	40
	Explanatory videos	48
	Complains from other teachers	34
	Carrying out a greater number of jobs	37
	Connectivity and online platform problems	51
	Effectiveness	68
Subjectivity	Empathy and adaptation from professors	46
	Overwhelmed-ness	13
	Stress/anxiety	11
	Lack of motivation	7

4.1. F2FL Model

What the students of the F2FL model value the most is direct communication with the teaching staff within the classroom itself, with 75% of the students talking about this idea in their answers, since if personal doubts or other questions arise, they can be resolved immediately. This allows the teacher to give explanations when the doubt arises, either with another example, giving other explanations, asking another classmate who has understood it to explain it or even being able to use manipulative materials to explain the doubt that has arisen. The students also mention that, in class, they must take notes of the teacher's explanations because they do not have videos to review these explanations as many times as they want or as they need, although they have at their disposal all the content of the subject on the campus through PDF reading documents and class presentations. Accordingly, it would seem that students are quite dependent on the teacher's explanations in the classroom, rather than on reading and understanding the documents provided on the subject's platform. Just over half of the students (51%) say that in the F2FL model

it is possible to give explanations in different ways for the better understanding of the subject and the use of manipulative materials to improve it, with 42% agreeing with this category. They highlight the advantage of carrying out practice, due to the practical nature of the mathematical subject, using manipulative materials in the classroom provided by the teacher; materials that they do not have at home or cannot print out due to a lack of means.

Likewise, the students emphasize as an important aspect of the F2FL model the fact of being able to work in a group in face-to-face lessons, with collaborative learning that encourages discussions and debates, and not a mere distribution of practical tasks that they must carry out and hand in. Specifically, 55% of the students support this idea. Although it is not an analysed category, we wish to highlight that 16% of the students mention the noise made by some classmates in the face-to-face model, something that does not happen in the EL model, because it is a totally virtual class where everyone has their microphone muted, so it is easier to listen to the teacher without interruptions.

Examples of student responses discussing the positive and negative aspects of the F2FL model (in comparison with the EL model) are:

- The explanations in face-to-face classes are clearer, since more didactic resources are used, and there is also greater participation and they are more dynamic, increasing motivation.
- It is more comfortable to practise the subject in person and in a group, where communication is easier.
- The number of students per class sometimes makes learning difficult.
- The noise from classmates or talking to the rest of the students in the class causes greater distraction.
- A disadvantage is that the classes are not recorded and if you forget something that you have not written down previously in your notes, you cannot see it again and it becomes more disorganized.
- The online lessons can be extended for a few minutes without worries, and everyone has the microphone muted which allows teachers and students who have doubts to hear clearly.
- Not being able to work with the materials in person makes everything very abstract and it is much more difficult to understand things.

The recommendations, which students express to improve teaching in the F2FL model, repeat the same ideas. On the one hand, they propose reducing the number of students per class, less repetition of each concept or idea explained and less content per class, to avoid information overload. They ask for more hours of practical lessons, with cooperative work and handling more material. They also ask to increase the number of face-to-face lessons to work on the different subjects of their grades. In general, talking about the rest of the subjects, they ask that the classes be more dynamic and participatory, and for recorded classes to be uploaded to the subject platform for the students to be able to listen to the explanations of the previous theoretical lessons again when at home.

Regarding effectiveness, almost all the surveyed students mentioned that the teaching in the F2FL model was effective, specifically 88% of students. Their answers refer to explaining that they prefer direct communication with the teachers, even non-verbal, since the sender receives signals from the receiver to know if they are communicating well or if they need to modify the way of expressing or explaining themselves in that instant. Students defend the idea that it is a degree where they have to learn how to teach and, from their point of view, the best way to develop social skills is seeing examples of their own teachers acting in the classroom and learning from them. They prefer to work face-to-face (not through a camera) with other classmates using manipulative and physical materials. Examples of student responses are as follows:

- Yes. Working through different activities, games, materials, and resources made me see Maths from a more fun perspective.
- Yes, because having everything physically, that is, a teacher who is explaining the contents to you in the moment, some classmates who are helping you in the moment,

some digital resources given, it is a much faster way when it comes to acquiring and enhancing knowledge in a subject.
- Yes, since it is better for both: the teacher who receives the student's feedback and for the student themselves, because if they have any problems they can ask the teacher the information and solve their doubts at the same time.

4.2. EL Model

For 44% of the students, the most important idea regarding the EL model is the flexibility of timetables, because the online class schedule can be extended without limitations according to their needs. Another idea shown in their answers is that, as microphones can be muted, meaning there are no interruptions from other students, there is much less noise during the class, and the teacher's explanations can be heard perfectly and clearly, and they were also more specific. The most notable positive aspect is that the online class could be recorded through the use of Google Meet or YouTube and, therefore, the students could watch it again whenever, however and as many times as they wished, and take notes with confidence. This category is supported by 48% of the students.

Another aspect that 40% students mention is the economic sphere, as they do not have to travel to the university on public transportation or share their cars with other classmates, as well as not having to spend money on rental accommodation (for those students who do not live near the campus). They even talk about their own availability, by not having to make trips that generate loss of time, they have more time to study.

Other categories selected from the original student answers are the complaints with respect to other teachers (34%) and the excessive number of assignments to be submitted (37%). A repeated idea we extract from the students' answers is that there were teachers of other subjects who asked them to submit more work than they would have asked for in the F2FL model, and they state that direct communication with the teacher is difficult when it comes to asking any questions while the online class is being taught. Furthermore, they repeat the idea of "problems with internet access" or that "the Moodle platform of the university was not working well and it crashed all the time", with the corresponding distress for students who could not follow the online lessons and their loss of time waiting for connection to be established, or having to change their resources to continue with the online class. They also highlight the lack of technological means on the part of the university with repeated technical problems in the Moodle platform, or of themselves, due to living in small towns or rural areas, or not having the effective means due to economic problems at home. They also emphasize the lack of digital resources, or having to share them with other members of the family, as well as taking into consideration good or bad internet connection at their own homes (13%).

Let us look at some examples of answers that corroborate these categories:

- Considerable money savings either in public transport or in renting the house.
- It becomes easier to attend because we are more available. Having more time to do homework and study while at home, without commuting. You are more self-efficient and the autonomy of the student is developed.
- Travel and economic cost. Travelling involves time and money that can be used for other, more important issues.
- There are people who do not have the resources to attend online lessons. The websites provided by the university are not effective enough.
- Some of the teachers have not taught or have not been concerned about their students, much less about the way they teach their subject. Another disadvantage is the overload of work we have been exposed to during this time.
- If you don't have access to the internet, you can't do anything—We don't all have the same resources—We don't all have a place to study at home—We don't all have our own room—We can't all be on the computer at certain times—We don't all have mobiles or laptops.

- Reduce the amount of homework, because two weeks before the final exams we have not been able to study yet due to the massive assignments we have to submit.
- Improve the apps where these lessons are taught, since many students are connected at the same time and it collapses.

Regarding the recommendations for improving the teaching of the EL model, they particularly mention the use of Google Meet or YouTube instead of the university platform due to the technical problems that it caused, or even using other online applications to teach and attend the lessons. However, what stands out the most are not the recommendations related to the use of technology, but rather the teaching itself, in the sense that they request a reduction in the volume of work to submit or the elimination of some contents from the curriculum to be taught. However, what they demand the most is understanding on the part of the teachers in the situation of home isolation, the lack of media or digital resources at their homes and a greater adaptation to the individual situation of each student.

To finish the analysis of the students' responses regarding the EL model, let us examine its effectiveness according to the students surveyed. There are three general answers: "yes", "somewhat" and "no". Those who answer "yes" are always thinking of the specific teachers of mathematical subjects (who carry out this study) and praising the involvement, effort, adaptation and means used by the teachers of that subject. In the second case, those who answer "somewhat" or "so so" or "yes and no" is because, although the teaching staff have adapted well to the circumstances, they prefer face-to-face lessons for the reasons already argued previously. Finally, those who directly say "no" do so because of their preference for face-to-face lessons, that is, the F2FL model, due to its direct contact with the teacher or classmates, and the other reasons stated above. Specifically, 68% of the students answered that the EL model was effective, but many of them conditioned their response because of the involvement of the teaching staff in these subjects, or the existing ICT resources, or they say "yes" but they prefer face-to-face.

4.3. Preferred Educational Model

Analysing the first of the two open questions of the third section of the questionnaire, we obtain the following results. The specific question about the preferred education model was posed and answered by the students always in consideration of the next school year in the pandemic situation and the possibility of returning to the classroom in the faculty. The students' answers are therefore conditioned by this, and they are not about the F2F, blended or electronic learning model in a general context.

Most of the students, 49 out of 100, prefer the F2FL educational model, particularly in order to be able to carry out working group activities in person. An indispensable part of learning is understanding and handling manipulative materials that as future teachers they will use in their classrooms with their students for better learning. They also prefer face-to-face classes for social contact with their classmates and to be able to carry out this practice in work teams with truly collaborative learning and not a mere division of tasks that each student must submit as a part of a group, which is what they did in the EL model of distance learning. They also mention the face-to-face contact with the teachers for a better understanding of explanations, to be able to ask questions in real time and so that the teacher can give more examples and explanations or carry them out in a different way. In contrast, in the EL model, it was difficult to ask questions while the teacher was teaching (even though they were allowed to).

However, 44 out of 100 students prefer a "mixed" class, understood by them as both face-to-face lessons—practical classes to be able to socialize, work in groups and have manipulative materials—and the e-learning method. Here the theory classes would be synchronous, that is, the teacher uses Google Meet or YouTube to teach online, or using asynchronous lessons recorded on video to be viewed by the students whenever, however and as many times as they wish, and even to stop them to be able to "take notes", as they say themselves, or to understand the explanations better. Therefore, from the students' own words, a third educational model can be introduced in this study that corresponds to

blended learning [14,16], consisting of face-to-face combined with e-learning lessons, that is, a b-learning model (BL) that combines classic pedagogical practices with others carried out online [13].

Only 7 people out of 100 would like to have wholly e-learning teaching, that is, to follow their training with the EL model entirely.

Below, we show the responses of the students themselves to each of the ideas mentioned above, where they express their desire to continue their training through the F2FL, EL or BL models:

- In general, I would continue with the face-to-face model, since in the theoretical lessons if you have doubts they are raised and resolved in the moment and you do not lose the thread as much as in an online class. And especially face-to-face lessons are much more effective to use the materials that we need to get to do the practices and that the whole group uses, and we can raise doubts about the work at the time.
- I prefer face-to-face teaching. It allows us to separate the place of work that is the university, and the place of rest, which is the house. Otherwise, with the e-learning method there is no timetable, so we have to be connected 24 h a day.
- Face-to-face teaching, since I see the lessons in the classroom more effective due to the explanations, doubts and teaching materials that this subject requires for its completion.
- My preference is mixed teaching, because it allows us to get to know and handle both methodologies that are important for our future profession as teachers. Besides, it could be a good option to the preference of all students.
- Mixed teaching combining face-to-face and online lessons so that some days we are at home to study and others at the university for work.
- I would like to continue with online teaching, as I have explained before, I find the explanations online better than in face-to-face due to the explanatory videos.

4.4. Subjectivity

A final open question was included in the data collection instrument to give the students the opportunity to express themselves freely, not only about teaching or the quality of the teaching/learning process, but also so that they could express their emotions and feelings resulting from the global pandemic situation or some other ideas that they wanted to express and had not already expressed previously in the autobiographical questionnaire. We have named this section "subjectivity" because we think that it is a word that represents what we are going to talk about: personal opinions not related with the educational models but students' feelings or worries about the situation they underwent.

The most prominent idea is the lack of empathy and adaptability of the university professor to the pandemic situation. They mention on several occasions that the teaching staff of other subjects have resources but do not know to use them, or do not pay attention to the students' needs, or only upload documents to the platform for reading and completing the assignments that they had to submit. They mention that other teachers have asked them to submit more work than that required at the beginning of the F2FL period, meaning that they have been swamped with work, with their corresponding submission deadlines being badly planned (showing a lack of coordination between teachers of different departments and the lack of attention of teachers of other subjects). They tend to blame others rather than taking responsibility themselves for the tasks. The category studied here is the empathy or adaptability of the teaching staff to the pandemic situation and to the transformation of the F2FL model to EL model, with 46% of the students talking about this idea.

Some responses related to these ideas are as follows:

- Most of the teachers, as a substitute for the face-to-face classes, have devoted themselves to uploading their documents and asking us to submit more tasks.
- It all depends on the teacher, if he or she wants us to learn, we will learn; but if they are not aware of their students during online lessons to see what we are doing, we do not learn anything.

- Many teachers, having insufficient resources, do not know how to carry out online teaching, which is not surprising, since it is the first time they have faced it and they are not offered the necessary materials to be able to carry out their work correctly. It is in these moments when we realize how undervalued education is and the few resources that are offered to both students and teachers.
- Teamwork has been devastating, as there is no physical space and relying on an online environment has been a disaster. It has been shown that the generation of "digital natives" is a fallacy, since there is nothing beyond social networks.

Other ideas mentioned by the students are related to their emotions. They talk about constant stress, feeling overwhelmed, anxiety, frustration, sadness, nervousness, suffering, worry. These are words from first- and second-year students, between 18 and 20 years old. Indeed, although it is not the scope of our paper, we think that talking about the students' feelings is important, in this case, in terms of the moral damage caused by the international pandemic. All ideas we extract from the original texts that are derived from the pandemic situation and home confinement are negative emotions, which can lead to a teaching and learning process that is neither optimal nor effective. Seven per cent of the students talk about a lack of motivation or feeling discouraged, which is caused by work overload or insufficient empathy shown by the teaching staff. All of this has discouraged the students, sapping their desire to continue studying or even making them consider abandoning their degree. Other students (13%) mentioned that the situation of home lockdown was tiresome and that they felt overwhelmed. The whole international pandemic situation was so important and complicated that they were unable to think about anything else, and many of them suffered from family economic problems. This also caused stress and anxiety in 11% of the students, who mention constant fatigue and the impossibility of concentrating on their studies.

Some examples of this are the following responses:

- It has been very hard in my opinion. I have been involved in very overwhelming situations, because everything that is happening affects you. If we add to the current situation that it is not possible to go out to "clear our minds" and that a large amount of work and study is required (not in this subject), a person is out of breath and strength, with no motivation.
- Well, for me, like many, I think it has been a constant burden and frustration, the overload of work sent by some teachers (not in this case) or the lack of information from others has made lockdown a suffering with the continuation of our training.
- The online teaching that we had to embrace due to COVID-19—I think that in my case it has been constantly linked to stress and fatigue.
- This situation has caused me constant stress.
- I believe that the priority is organization and sympathy towards the students to maintain motivation and obtain positive results.
- Where is the motivation to learn? Because I have felt like a robot.
- The first semester I was very motivated and kept everything up to date, but it is true that this semester it is taking me a lot to study. I know that this is going to lead to worse grades than I could have in other circumstances.

4.5. Resources Used by the Teaching Staff

The last part of this research to be highlighted is the assessment that the students made of the resources used by the teaching staff in each of the previously described teaching models, F2FL and EL.

As mentioned previously, within the questionnaire there was a specific section dedicated to evaluating the resources used, rated (on a Likert scale) from "very useful" (5) to "not very useful" (1), even giving the option of "don't know/no answer" (NK/NA). The resources used by the teaching staff included in the questionnaire are shown in the first column of Table 2, together with the percentages for each value in the Likert scale and its mean value. All items show values up to 4, except the PDF readings and working

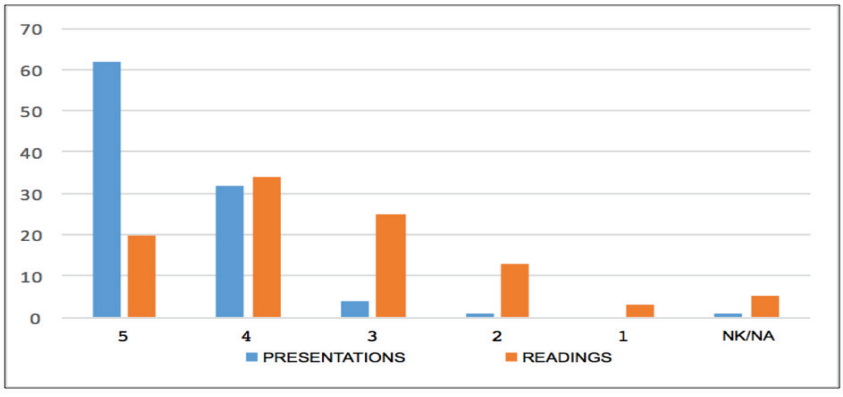
individually. These items are the worst valued by the students, with 21% and 33.7% of them indicating that the item is very useful, respectively. In contrast, the most useful items are communication (78%), video/YouTube theoretical lessons (73%), and F2F practical lessons (70%). These results show the same ideas as the students' words in the previous sections, focusing their attention on communication with the teacher, online theoretical lessons and F2F practical classes.

Table 2. Percentages of each value in the Likert scale and media value for resources used by the teaching staff.

Resource	5	4	3	2	1	Media
PowerPoint presentations	62.7	32.2	4	1	0	4.56
PDF readings	21	35.8	26.3	13.7	3.2	3.58
F2F theoretical lessons	60.2	24.5	10.2	5.1	0	4.4
Video/YouTube theoretical lessons	73	20	5	2	0	4.64
F2F practical lessons	70	21	8	1	0	4.6
Meet/YouTube practical lessons	54	33	7	5	1	4.34
F2F meetings with the professor	55.5	23.8	14.3	4.8	1.6	4.27
Meet/YouTube meetings with the professor	64.6	22	8.6	2.4	2.4	4.44
Working individually	33.7	13.7	19	21	12.6	3.35
Working in group	49	27	15	6	3	4.13
Individual works	44	31	13	9	3	4.04
Group works	50	36	9	3	2	4.29
Notices	51	29.6	9.2	7.1	1	4.18
Schedule	63.7	21.1	13.1	2	0	4.46
Communication	78	19	3	0	0	4.75

The most relevant results are also shown in the figures below, in which the Y axis shows the number of students, and the X axis the Likert scale (values between 1 and 5) and the NK/NA answer. Figure 1 (top) corresponds to the assessment by the students of the teacher's explanations compared to the reading of PDF documents by themselves. The PowerPoint presentations of the subject content by the teacher were rated as very useful by 62.7%, as opposed to focusing on readings (articles or books) by themselves (21%) and studying independently. Moreover, 73% of students consider the recorded videos to be more useful, so as to be able, in their own words, "to watch the video as many times as they wish", as well as to be able to stop it at any time to take notes on the presentations or explanations from the teachers. In Figure 1 (bottom), the scores of the students of the face-to-face theoretical lessons are shown versus the online format recorded on video or YouTube channel.

In Figure 2 (top), the scores of the practical lessons are shown in the face-to-face model compared to the same type of lesson but online. What the students said is that the former, the face-to-face lessons, are more useful than the latter. Related to this, Figure 2 (middle) shows the students' assessment regarding the way of working (individual versus group), considering working in groups as more useful than individually. Finally, Figure 2 (bottom) shows the students' assessment of the usefulness or the uselessness of the use of notices on the online platform of the subject, as well as a schedule of the subject created by the teacher, and the communication of the students with him/her, with the latter being the best rated by the surveyed students.



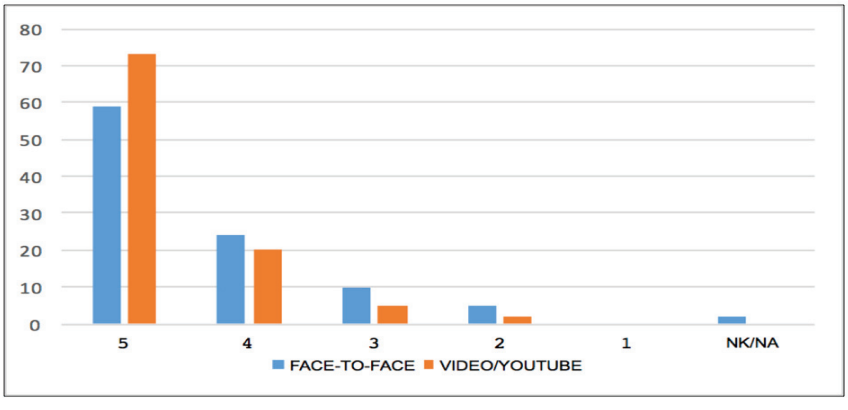


Figure 1. (**top**) Comparison between the teacher's presentations versus reading of documents. (**bottom**) Comparison between the face-to-face versus online theoretical lessons.

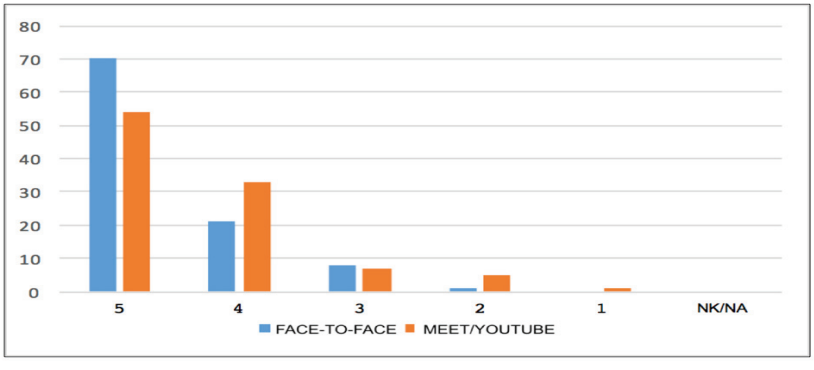


Figure 2. *Cont.*

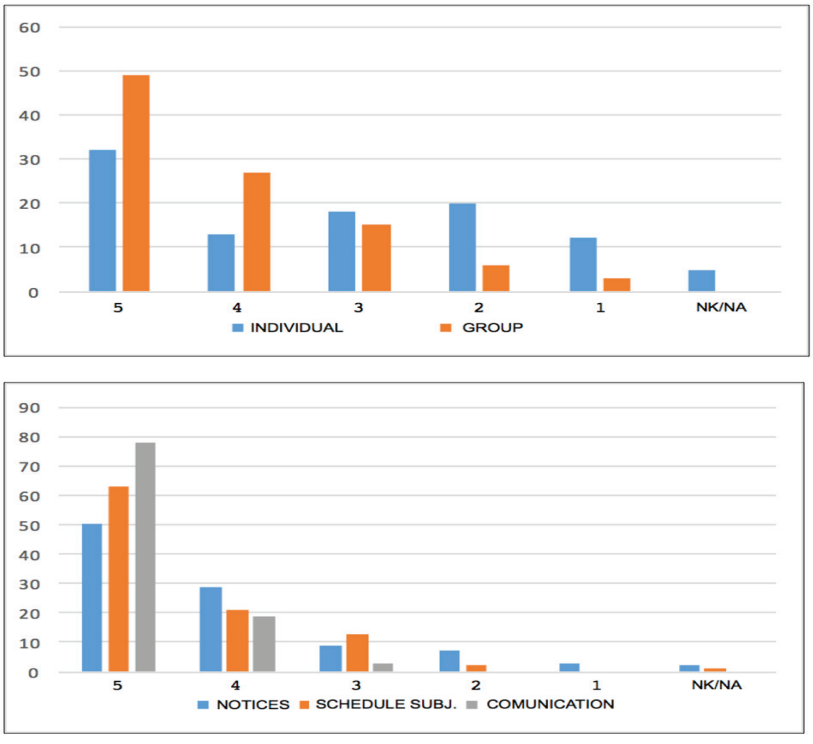


Figure 2. (**top**) Comparison between the face-to-face versus online practical lessons. (**middle**) Comparison between working in a group or individually. (**bottom**) The students' assessment related with the use of notices, schedule of the subject and the communication with the teacher.

From the assessment by the students shown in the previous figures, Table 2 and previous explanations, it may be deduced that there is a clear tendency or predilection of the students to the BL model, where the teacher explains the knowledge of the contents related to the subject in question, in class, but being recorded, and the video is then made available to them rather than in a face-to-face lesson (the mean value of video/YouTube theoretical lessons is 4.64; and the PowerPoint presentations is 4.56). They also prefer F2F practical lessons (mean value of 4.6) and work in a group rather than individually. Likewise, they positively rated the planning of the subject (4.46) and its development by the teaching staff, as well as having good communication (4.75), thus emphasizing their dependence on the teacher.

5. Discussion

An important component of learning in the classroom is the social and communicative interaction between the student and the teacher, and between students themselves. The students' ability to ask a question, share an opinion, or disagree with a point of view is a fundamental learning activity [30]. Through conversation, speech and debate, a new concept is clarified or a skill is practised. This direct interaction is precisely one of the main demands of the students in this study, the same result found by Johnson et al. [22]. The results show that by not having the opportunity for face-to-face interaction and instruction, most of the students were not satisfied with the EL educational model of online lessons, which affected their motivation and willingness to follow the subjects, preferring the face-to-face ones. This result is consistent with the studies by Altunay [17] and Gunes [19]. In addition, Muzammıl, Sutawıjaya and Harsası [31] conclude that interaction

(between students, or students and tutors) is an important variable and has a positive effect on student satisfaction.

In addition, we can conclude from the results that students demand greater coordination between teachers of different subjects, better communication, and greater sympathy on the part of teachers regarding the situation of stress, overwhelmed-ness and frustration generated by COVID-19. Likewise, they express their dissatisfaction with the excess of tasks and work that the teachers require them to submit, as well as the lack of participation or follow-up or attention on the part of the teacher towards the students. This conclusion is also drawn in the studies by Trujillo et al. [4] and Demuyakor [6]. Similarly, Landrum, Guilbeau and Garza [32] also talk about this teacher–student interaction, where this dialogue "implied a constant tension between the self and the other, the activity and the passivity, giving and receiving, the preparation and the spontaneity, to instruct and learn, to direct and follow, to affirm and withdraw".

In terms of results in favour of the EL educational model, students indicate its time flexibility, meaning they can study in their own time and from their own place, which was also found by Bagrıacık [33], and in the benefits of the EL model by Rosenberg [9] and Area and Adell [10]. The reduction in economic expenses, less noisy lessons and the availability of recorded lessons, are mentioned by the students as advantages of the EL educational model. However, they also focus their attention on the technical problems of the university platform, lack of or bad connectivity to the internet from their homes, or lack of technological gadgets (computers, tablets or mobiles). The same results are shown in the works of Altunay [18], Demuyakor [6], Muthuprasad et al. [7], Noviana, Sukardi and Suryanti [21] and Trujillo et al. [4]. In particular, it is essential to mention the study by Rodicio-García et al. [34], where they carry out a study on the digital divide in university students.

Finally, it should be noted that although students prefer an F2FL model (49%), there is a high percentage (44%) of students who, in order to continue with their training process, would be in favour of a BL model, and only 7% would be happy to continue their education with a fully remote EL model. Almost the same percentage of students would prefer to continue their training in the next academic year with an F2FL or BL model. However, we want to emphasize that their answers to the questionnaire are conditioned by the pandemic, in the sense that they and the teaching staff thought that the international COVID-19 situation would not be under control, and that in the next academic year all of us would have to make further adaptations. The authors believe that this is the real reason why the second option of educational model for the students was the BL model. For them, the BL model is understood as having access to theoretical lessons recorded or synchronous online, and to other documents or material available online, and more hours of face-to-face practical lessons to be able to have access to manipulative materials, to interact with the teacher and the rest of the classmates. This is the same conclusion that Gunes [19] and Chandra and Fisher [15] make in their studies. Hussein et al. [35] state that many students still prefer the traditional learning approach, but the number of students in the e-learning field is increasing and that an adaptive e-learning approach does not only enhance content construction but also domain knowledge and pedagogy.

Finally, we would like to highlight the aspect of subjectivity that emerged from the analysis of the original fragments of the questionnaire answered by the students. From their own answers, the main idea is the lack of empathy and adaptability of teachers to the new pandemic situation. Almost half (46%) of the students complain about the lack of attention received from their teachers, who only upload documents and set new assignments (not planned at the beginning of the course), but do not give online classes. This causes demotivation and negative emotions. Thirteen per cent of the students say that they feel overwhelmed due to home confinement, isolation, or having family problems. A further 11% of them express feelings or emotions of stress and anxiety with constant fatigue and the impossibility of concentrating on their studies. They are worried about their training and education, as well as the global pandemic situation. In this sense, we

wish to highlight the study by Valero et al. [36], in which they compile studies that analyse how the global pandemic has affected the mental and emotional health of individuals, as well as self-care strategies in home isolation. That is why it is understandable that the surveyed students show these feelings, in the same way as any other individual who is suffering a similar situation, since they also want to achieve academic success, which in itself creates anxiety and even more if we relate it to mathematics. As Tuncer and Yilmaz [37] show that there is a positive relationship between achievement and success in the mathematics class and the attitude of students, with the relationship with anxiety being negative, as well as the relationship between anxiety and attitude being negative and significant. We should also mention the study by Zang et al. [38], who assess the adverse impact of the COVID-19 outbreak on Chinese college students' mental health, seek to understand the underlying mechanisms, and explore feasible mitigation strategies. Their results show that 85% of respondents reported their worries about COVID-19, and over 20% reported at least one form of mental distress, and the prevalence of negative emotions was higher than in previous studies. Moreover, they say that the isolated home situation and social distancing for a long time might cause irregular lifestyles with poor sleep quality, stress and anxiety over their academic or future career. It is therefore normal that our students feel these emotions of stress, anxiety, overwhelmed-ness, and the need to share them with other people—in this case with the teachers—and they complain when the teaching staff do not pay attention to them.

6. Conclusions

The COVID-19 pandemic situation has affected many areas of life, including education at all levels. Universities and other institutions were forced to close and change their way of teaching from an F2FL model to an EL model. We consider that it is important to discover the perceptions and opinions that students have of their training process if we want this process to be effective and meaningful, both in a pandemic situation and simply as a future learning model. In summary, our research, a survey about the perceptions and opinions of university students, produces the following main ideas.

Firstly, in favour of the F2FL model, the students demand social interaction with the teacher and with each other, to ask questions or voice doubts directly in class, or to have the possibility to manipulate physical material and work in groups with collaborative learning. As many as 88% of the students say that the F2FL model was effective and 49% of them would like to continue their training with this model. Negative aspects of F2FL model were that the F2F lessons are not recorded, and that the classes could be noisy and have interruptions.

Secondly, in favour of the EL model, the students note the idea of timetable flexibility, more silence during the class (the teacher's explanations can be heard perfectly), economic aspects, recorded lessons and more time to study at home. Their negative ideas focus on technical problems, excessive assignments and the lack of teacher attention. Of the students, 68% say that the EL model was effective, but only 7% would continue their learning process using it.

A further 44% of the scholars would carry on their teaching/learning process with a BL model. This consists of a mixed model between F2FL and EL, with synchronous or recorded theoretical lessons, and F2F practical classes to socialize, work in groups and manipulate materials.

The last idea we wish to highlight concerns subjectivity. A fourth open question was included in the questionnaire where the students could express what they wanted. In this question, 46% of them mention the lack of empathy and adaptability shown by teachers of other subjects, and the excess of assigned work. Additionally, 13% of them say they feel overwhelmed and 11% mention stress and anxiety.

The COVID-19 pandemic is still present today and education institutions or specific classes could be closed or isolated due to positive infection cases. Performing research on how to increase the quality of the teaching/learning process and how a dramatic situation

emotionally affects students is paramount. We are aware of the limitations of our research and that additional studies on students' preferences are important and need to be carried out.

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Article

Internship of Accounting Students in the Form of E-Learning: Insights from Poland

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Abstract: The COVID-19 pandemic has imposed on us not only e-learning with higher education providers, but also triggered considerable difficulties in organization internships. Institutions and enterprises that used to be eager to take interns have refused to do so. In these conditions, the key objective for the Faculty of Management at the UTP University in Bydgoszcz was to organize e-internships to ensure a working environment similar to the real working conditions of the accounting department. A new internship program was developed that implemented the assumptions of active learning, by virtue of the case study approach, computer-based learning environments, and a comprehensive task simulating the work of the accounting department in the form of a multi-step project. The key objective of this article is to present the results of research in the form of a survey on how the students majoring in Finance and Accounting perceive the proposed internship method. The results show that an internship in the form of e-learning with the proposed education methods is appreciated by the students. E-learning does not necessarily have to be less effective than traditional learning. The use of platforms and the selecting of adequate methods can enhance the activity of students, supporting self-education and independent task performance.

Keywords: e-learning; accounting education; COVID-19; internship; higher education

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1. Introduction

An essential part of the education program offered by providers of higher education is an internship, which creates a real work environment wherein students can develop the knowledge and skills acquired with hands-on experience. Internships create conditions for practical training, and are regarded as a key element in enhancing employability, as they help graduates acquire the work-related skills demanded by employers [1].

The COVID-19 pandemic and the restrictions introduced in respective countries have not only imposed e-learning on higher education providers, but also triggered considerable difficulties in the organization and implementation of internships. This concerns especially the Finance and Accounting major, for which, naturally, internships are held in service-rendering enterprises, with local authorities, and in the accounting departments of various companies. When exposed to the pandemic, many enterprises and institutions, having to limit contacts between people, introduced shiftwork or "hybrid" work. A substantial group of administration and office personnel have since been mostly working from their home office. Due to these limitations, organizations and enterprises that, in most cases, used to be eager to take interns, have refused to do so. For Universities, this poses a big problem. The regulation introduced by the Minister of Science and Higher Education obliges the higher education providers to follow a full education program, including internships.

Under these new difficult conditions, the challenge of organizing internships for B.A. students majoring in Finance and Accounting was faced by the Program Committee of the Faculty of Management at the UTP University in Bydgoszcz. Taking up the challenge, it was assumed that internships would be provided by academic teachers with practical accounting experience, e.g., accounting enterprise owners or employees. The key objective

was to organize internships in the form of e-learning (e-internship) to ensure a working environment similar to the real working conditions of the accounting department or accounting enterprise, and, as a result, ensuring the quality of education for that part of the study program at an unreduced level in relation to the traditional internship. This was a particularly difficult task, as teachers were not trained in online pedagogies. Yet another challenge involved providing internships that would ensure active student participation.

E-learning is an important part of the educational system in the 21st century [2]. It can be considered as a natural evolution of distance learning, and means adopting electronic educational technology in the learning and teaching process [2–5]. E-learning covers a wide set of applications and processes, such as web-based learning, computer-based learning, virtual classrooms, and digital collaboration [6]. E-learning can deliver the content in different forms; for example, lectures/videos on-demand, multi-media components [3,6], various types of electronic files, or as online lectures and courses. Two content delivery modes can be used: online, where the teachers and students meet at the same time, and offline, when educational materials have been made available in advance on the e-learning platform and students can use them at any time. E-learning places fewer restrictions on learning [7] as students can learn in any place (online and offline modes) and at any time (offline mode).

E-learning is a new and ground-breaking approach to serving the needs of learners [8]. However, the results of studies on the effectiveness of e-learning education for economics majors are ambiguous [9]. Many recent studies point to there being no essential differences in learning outcomes for online, hybrid, and traditional accounting students, and even suggest an advantage in distance learning over face-to-face learning [10,11].

According to some studies, the quality of e-learning education depends on the course contents and the students' qualities [12–15]. The authors assume that pandemic-imposed e-learning does not always translate into a decrease in the quality of education, and that it can be appreciated by students. The abovementioned factors on which the quality of education depends must also include a selection of the most adequate teaching methods, as well as preparation, involvement, and the approach of the teacher to the students.

The key objective of this article is to present the results of a survey on how the proposed internship method is perceived by those students majoring in Finance and Accounting at the Faculty of Management of the UTP University in Bydgoszcz, in the second and the third year of their B.A. program. The results of the empirical study are preceded by indicating the teaching methods used by accounting students for internships and those recommended in the literature, discussing the internship method, the contents, and the formative assessment that was used to assess student performance and progress.

2. Teaching Approaches and Methods Recommended in Accounting Education

The approach to accounting education and the methods most frequently pointed to in the literature, and recommended by various international and domestic accountant associations, cover:

- Active learning approach;
- Case study method;
- Computer-based learning.

Active learning has been strongly recommended in accounting education as a very effective teaching method for more than 30 years [16–18]. The participatory approach to teaching results in positive outcomes for students, and optimizes learning [19–23].

An active approach makes it possible to keep students engaged in the learning process and to ensure feedback, as a very important part of the education process [24,25]. Active learning techniques in accounting courses provide students with an enhanced opportunity for learning and for having a better sense of the actual work of accountants [26].

Case studies are considered one of the most important methods supporting active learning and, as such, they are promoted to encourage accounting students to become active and independent learners [27–34]. In particular, the students consider real-life case studies,

as these effectively supplement their accountancy tutorials [35]. Stanley and Marsden [36] have shown that solving real-life cases develops the ability to ask questions, to work in teams, and to solve real problems. In the accountant's education, case studies and real-life cases are used to reflect the actual work of accounting departments or accounting firms. Although studies by Stejskalowa et al. have demonstrated that the use of real-life case studies in accounting is more effective than applying hypothetical examples, case studies can be successfully combined with the simulation-based approach [37].

In order to perform their tasks, accountants use financial and accounting software, which is one of the reasons why computer-based learning (CBL) and information technologies (IT) have been a recommended teaching approach for educating accountants for many years. As early as 1995, the International Federation of Accountants (IFAC) was stressing in the International Education Guideline No. 11 (Information Technology in the Accounting Curriculum) that technology needs to be a key component in the accounting curriculum. This guideline was adopted without modification by the American Institute of Certified Public Accountants in 1997, revised in 1998 and 2002, and it is now known as Education Practice Statement 2 [38]. The importance of having IT skills for the accounting profession was also confirmed by the Pathway Commission [39].

In addition, many scientific studies highlight that Information Technology and Information Systems are very important components of accountancy curricula, and that IT skills are one of the most desired skills for accountants [40,41]. According to a study by Halabi et al. [42], who compared the effectiveness of computer-assisted learning to a traditional face-to-face lecture, computer-assisted learning is more interesting and stimulating than other methods of instruction, and it is an easy way to learn. The importance of presenting accounting principles in the IT environment is underlined by Jaijairam, who claims that "*presenting accounting principles in student-centered and computer-based learning environments can demonstrate the practicality and necessity of the subject, particularly as a foundation for many career options*" [43]. Chen et al. [44] stated that accounting educators should integrate the relevant IT topics into the traditional accounting core subjects, so that future professional accountants remain competitive and pertinent in the new and changing environment. Their findings indicate that new accounting graduates are expected by their employers to be able to use, e.g., spreadsheets, small business systems, and computerized accounting packages.

In addition to the teaching approaches and methods described above, multi-step projects are also indicated as important in accountancy education to help students better understand the accounting cycle, and develop the appropriate problem solving and technology skills [45].

When preparing the internship program, efforts were made to apply all of the above-mentioned approaches and methods.

3. The Scope of the Internship Provision Method and the Students' Assessment

The coronavirus (COVID-19) pandemic has triggered huge changes in education at all levels. Universities have been searching for a way to use e-learning tools for executing framework syllabi, making the education process more involving and efficient, and enhancing the higher education system [3].

The internship is an important and a mandatory part of the Finance and Accounting education program for all students. As it is not possible for the students to serve their internships in a real accounting environment, the Faculty of Management of the UTP in Bydgoszcz has developed a program and organized internships in the form of e-learning; these approaches are a hybrid of online and offline, and are addressed to the second- and third-year students. The e-internship was provided in three periods: two-week internship for the second- and the third-year students in September 2020; four-week internships for the second-year students in December 2020 and January 2021, and four-week internships for the third-year students in January and February 2021.

3.1. The Scope and Internship Provision Method

The internship was supervised by the academic teachers of the Faculty of Management of the UTP in Bydgoszcz, with practical enterprise accounting knowledge and experience as accountants. It was held in the form of e-learning on the Microsoft Teams platform, with the use of the Rewizor GT finance and accounting program, as part of the integrated Enterprise Resource Planning (ERP) class package devised by Insert.

The internship supervisors used the case study method to facilitate combining the students' knowledge with practice of an enterprise operation. A comprehensive task was applied; a case study simulating the work of the enterprise's accounting department, developed by the internship supervisors and compliant with the multi-step project method's assumptions. The task used during the September internship of the second-year students simulated the work of the accounting department of a trading enterprise, while during the internship of December 2020 and in January and February 2021, it was a production enterprise.

During the online internship, the students:

1. Got to know the organizational structure, the subject of activity, and the organizational and legal form of the enterprise;
2. Got to know the policy and the accounting principles, the corporate chart of accounts, the principles of keeping accounting ledgers, asset recording, asset valuation methods, unit settlements, costs, revenues, and the principles of determining the financial result in the simulated enterprise;
3. Got to know the functions of the Rewizor GT finance and accounting program as part of the integrated ERP class package;
4. Identified information and document flow in the enterprise.
5. Took successive actions in the Rewizor GT system related to the execution of a comprehensive task. They created respective files and a chart of accounts plan, assigned economic operations, defined the connections between accounts and respective items of the balance sheet and profit and loss account, and generated different breakdowns (for a detailed breakdown of the students' tasks in the Rewizor GT system, see Table 1).

Table 1. Students' tasks performed in the form of e-learning in the finance and accounting system.

Finance and Accounting Program Module	Tasks
Implementation data	entering the enterprise details determining the VAT settlement method defining the ledgers entering program parameter settings
Files	supplier data entering institutions fixed assets
Chart of accounts	entering the chart of accounts compliant with the accounting policy of the enterprise defining the control accounts and keeping subsidiary ledgers accounts to the first level of analytics entering the initial balance of the accounts; drawing up an opening balance
Assignment and bookkeeping	assignment of economic operations resulting from the task performance
VAT purchase register/VAT sales register	control of the correctness of the documents entered analysis of the value of the output and input tax

Table 1. *Cont.*

Finance and Accounting Program Module	Tasks
Settlements	settlement control settlement of accounts balance confirmation
Fixed assets transactions	creating files for fixed assets fixed asset recording defining depreciation schedules calculation of depreciation drawing depreciation table for a selected period
Statements	defining the closing balance defining a profit and loss account in the calculation variant
Tax returns	drawing up JPK_VAT7 tax returns defining and drawing up tax returns; monthly CIT advance payments
Breakdowns	trial balance bookkeeping journals analysis of financial liquidity

Source: own elaboration.

During regular online Microsoft Teams platform meetings, the internship supervisors explained successive sub-tasks to be executed as part of a comprehensive task to the students. Then, the students solved the tasks offline and unassisted, after which, during the scheduled online consultations, they discussed any problems with an internship supervisor. At the end of the online internship, the students provided breakdowns and reports developed in the finance and accounting program on Microsoft Teams, the accuracy of which was evaluated by the internship supervisor.

3.2. The Students Assesment

According to the internship supervisors, the case study method provided the students with the possibility of independently performing successive task stages, and the comprehensiveness of the tasks facilitated their understanding of a full cycle of economic events register, starting from recording the documents, through bookkeeping, and drawing up facultative breakdowns and obligatory reports.

To evaluate the work of the students, the formative assessment method was selected, which provided regular feedback to the interns and monitoring of their progress. The basic idea of formative assessment is that the central purpose of learning is to contribute to student learning through the provision of information about performance [46]. This helps to gather evidence for the purpose of improving student learning by providing teachers and students with continuous, real-time information that informs and supports instruction [47]. The formative assessment is viewed as an integral part of the teaching–learning process, and encompasses the following elements: shared learning targets and criteria for success, feedback that sustains forward learning, student self-assessment and peer assessment, student goal setting, strategic teacher questioning, and student engagement in asking effective questions [48]. In the formative assessment, teachers and students focus on learning goals and take action to move closer to them [49].

The formative assessment elements in the e-internship provided at the Faculty of Management of the UTP University of Science and Technology for students majoring in Finance and Accounting are presented in Table 2.

Table 2. Elements of formative assessment adapted for e-practice.

Element of Formative Assessment	Actions Taken in E-Internship
Learning targets and criteria for success	Instructors explain to students the practice goals, tasks to be performed, and success criteria
Dialog	Students and instructors conduct discussions, ask questions, use "brainstorming" in order to systematically carry out tasks
Collaboration	Students pass on to instructors and exchange information about completed tasks Students exchange information on how to perform tasks and check the correctness of the results
Feedback	The instructors provide students with feedback on the correctness of the task completion and the fulfillment of the agreed success criteria Students understand the goals they are pursuing and use the feedback to complete and correct tasks
Adjustments for continuous improvement	Instructors constantly motivate students by adjusting tasks to their needs in order to achieve the set goals

Source: own elaboration.

At the beginning of the e-internship, students were informed about its goals, tasks to be performed, criteria for its evaluation, and the possibilities of communicating with the instructors. The instructors systematically assessed the work and progress of students, taking into account their ability to apply theoretical knowledge to perform practical tasks, reading and understanding documentation, their ability to correctly and accurately perform tasks, as well as their teamwork during the assigned parts of practical tasks. After each class, students sent the results of the tasks to the lecturers in order to obtain feedback on the correctness of the task completion. At the end of the internship, students prepared lists containing the results of the performed tasks. Then, they obtained feedback from the instructors, including the analysis of the results sent, which indicated possible errors and their causes, and the final evaluation of the practice.

In the opinion of the instructors, the use of formative assessment made it possible to systematically assess the students' progress, motivated them to work, and ensured the effective implementation of the next stages of the project.

4. Methodology of Students' Opinions Research

While developing an internship program in the form of e-learning for the students majoring in finance and accounting, the specific nature of the accounting course as well as the possibilities offered by e-learning platforms were considered. The persons responsible for e-learning internships considered the choice of the case study approach in combination with a multi-step project applied in a computer-based learning environment with the use of a finance and accounting program to be adequate. In their opinion, active learning was successful and engaging for the students in successive stages of a comprehensive task. In the opinion of the internship supervisors, good contact with students was achieved.

To confirm the positive observations made by internship supervisors, a survey study with students was launched.

The key objective of the empirical study was to get to know the opinions of the students in terms of the internship in the form of e-learning, mixed between online and offline approaches, as proposed by the Faculty of Management.

The goals included:

1. Getting to know the opinions of the students on the method of organization and e-learning internship;
2. Getting to know how the students perceive the internship supervisors;
3. Getting to know the students' opinions about the skills acquired throughout the internship;

4. Indicating the advantages and disadvantages of an internship served in the form of e-learning;
5. Indicating the issues that can be successfully covered in the form of e-learning and those which should be covered in a more traditional manner.

The following research questions were also asked:

RQ 1: Does the evaluation of the internship depend on the year of the studies?

RQ 2: Does the evaluation of the internship depend on the distance of the student's place of residence from the Faculty of Management?

RQ 3: Do students taking up a job during their studies value an e-learning internship higher than the others?

When asking the first question, it was taken into account that third-year students had completed a traditional internship in an accounting office or accounting department before the pandemic and could, therefore, compare it with the proposed e-learning internship, whereas second-year students did not have such an option.

When asking the second and third questions, they were guided by the results of the research provided in the literature, and the observations of the authors who have been teaching remotely for over a year. Studies by Ng [50] have shown that students who have other essential professional and family duties benefit from e-learning most. The students appreciate the flexibility in managing their schedule and avoiding travel [10], and the benefit of having the possibility of choosing the time and place of learning. Flexible teaching hours in distance learning allow students to combine study and paid employment [51]. Many regular-program students at the Faculty of Management take up a job that pays for their living, and apply for an individual course of study. Distance learning, which enables the student to be at work and participating in classes at the same time (as is confirmed by the experience of the lecturers), creates much greater possibilities for receiving credits than traditional learning, where the student must participate in person in classes provided at the University.

The study involved an online survey. The survey questionnaire included 8 closed- and 6 open-ended questions. The closed-ended questions used a 5-degree Likert scale [52], where 1 stands for "definitely negative" and 5 for "definitely positive".

Additionally, the respondents were asked to provide the distance between their place of residence and the location of the Faculty of Management, and whether they have had a job during their studies.

The questions were divided into 5 groups. The first group of questions concerned the total score awarded by the students for the internship and its organization as distance learning, and the score awarded to the tutor/supervisor. The second group of questions was related to the evaluation of the internship supervisors. Responding to the fifth group of questions, the students were asked to evaluate the general skills acquired, such as groupwork, organization of own working time, independent solving of tasks, and specific content-wise issues related to accounting practice (the skill of keeping business records, finance and accounting program operation, etc.). The fourth group included questions concerning the opinions of the students on the advantages and disadvantages of the internship method, and the technical, mental, and health difficulties faced. The last group of questions addressed the students' recommendations in terms of an internship that can be successfully provided as e-learning, what they should definitely get to know in the enterprise, and if the form of internship matters to them.

The survey questionnaire was provided to the students via Google forms from 11 January to 5 February 2021.

5. Research Results

In the 2020/21 academic year, the number of students majoring in Finance and Accounting in the second year of studies was 100, and in the third year 93. The internships organized in the form of e-learning by the Faculty of Management of the UTP in Bydgoszcz were served by 36 second-year and 60 third-year students. The other students served their

internship in a traditional manner; in accounting firms, or departments of finance and accounting of various enterprises and institutions. The survey questionnaire was properly completed by 33 second-year and 33 third-year students. Women accounted for 68% of the respondents and men for 32%.

5.1. General Evaluation of the Internship Method

Following the research objectives, the authors first analyzed the responses to the questions on the students' evaluation of the internship in the hybrid form of distance learning. The first question aimed at a general evaluation. The results are presented in Figure 1.

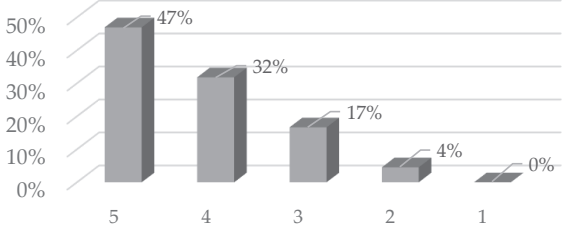

Figure 1. What score do you award to the e-learning internship?

In total, 47% of the students considered the internship as very good, and 32% good. Only 17% of the respondents awarded an average score, by which the classes were evaluated to be satisfactory, and only 4% of the respondents gave a negative score. A more detailed analysis shows that the opinions of the second- and third-year students do not fully overlap (Table 3).

Table 3. General evaluation of an internship in the form of e-learning by the second- and the third-year students.

Grade	Second-Year Students	Third-Year Students
5	61%	33%
4	30%	33%
3	9%	24%
2	0%	9%
1	0%	0%

Source: own study.

A higher score was awarded by the second-year students. In total, 61% of the respondents gave a very good grade, and the successive 30% described it as very good. Nobody considered it definitely negative or negative. Of all the third-year students, 33% graded the internship as very good, and the same number of interns considered it good (33%); 24% considered the internship method as on average satisfactory, and 9% negative.

The students were also asked whether the time allocated to the internship was optimally used, whether the internship ensured the possibility of the practical application of the theory, and whether the number of practical tasks and jobs to do was sufficient (Table 4). The answer "definitely yes" or "rather yes" to the first question was given by 45% and 39% of the second-year students, respectively. Slightly more skeptical were the third-year students (30% and 45% of the answers, respectively). In both groups of students, the appreciation of the possibility of applying the knowledge of theory in practice was slightly lower as well. It was considered to be definitely positive by 39% of the second-year students, and 21% of the third-year students. The answer "definitely yes" to the third question was given by 33% and 18% of the second- and third-year students, respectively;

48% and 45% of them were slightly less convinced. Only an insignificant number of the respondents provided a negative or rather negative response in terms of the internship.

Table 4. Evaluation of the use of time, possibilities of practical use of the knowledge acquired and acquiring practical skills.

Students' Opinion	Was the Internship Time Optimally Used?	Did the Internship Make It Possible to Apply the Knowledge of Theory in Practice?	Was the Number of Practice Tasks and Jobs to Do Sufficient?
Second-year students			
Definitely yes	45%	39%	33%
Rather yes	39%	39%	48%
No idea	12%	15%	9%
Rather not	0%	3%	3%
Definitely not	3%	3%	6%
Third-year students			
Definitely yes	30%	21%	18%
Rather yes	45%	48%	45%
No idea	15%	18%	12%
Rather not	6%	9%	18%
Definitely no	3%	3%	6%

Source: own study.

Interesting observations can be derived by analyzing the results depending on the distance of the student's place of stay from the location of the Faculty of Management, the UTP. The internship was most appreciated by the group of students staying furthest from the headquarters of the Faculty of Management. The group of students living further than 50 km away awarded an average grade 4.5, and the group of students residing 16 km to 50 km gave 4.3; the average grade given by the students staying closer was 3.9 (Figure 2).

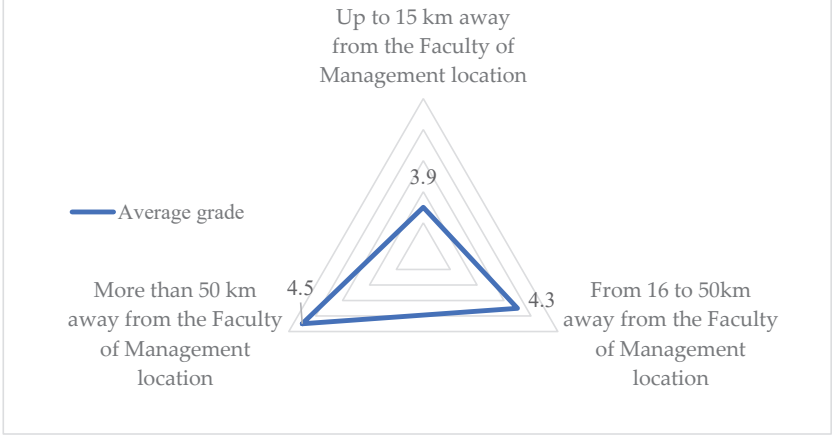

Figure 2. Evaluation of the internship depending on the distance between the student's residence and the location of the Faculty of Management.

A lower variation in the grade awarded to the internship is noted when considering the criterium of having a job (Figure 3). The e-learning internship was appreciated the most by the students who did not have a job prior to the outbreak of the COVID-19 pandemic and who have a job at present (an average grade of 4.5), those who used to have a job, and

then by those who lost their jobs due to the pandemic (the average grade in that group was 4.4). The lowest grade (4.1) was awarded by those students without a job.

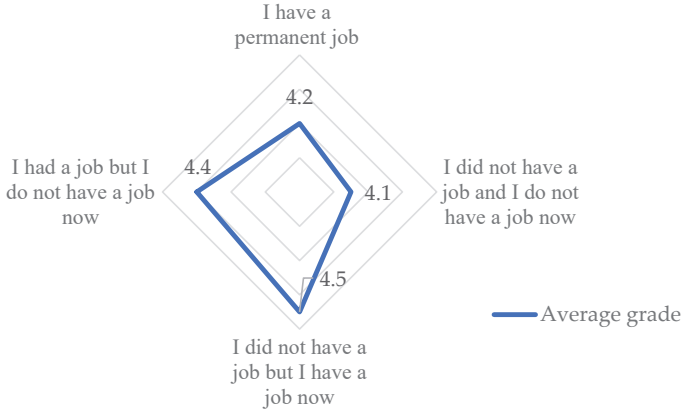

Figure 3. Internship evaluation by students with a job and without one.

5.2. Evaluation of the Internship Supervisors by Students

The students also evaluated the internship supervisors. The students were asked to evaluate eight aspects of the attitude of the internship supervisor towards students, as well as the internship method (Figure 4). They appreciated the kindness of the tutor most; as many as 76% of them awarded very good grades. Then came punctuality, with 74% of such grades. The method of internship evaluation was also given a high grade. In terms of the possibility of communication and involvement, 68% and 64% of the students, respectively, awarded very good grades. Compared with the other aspects, the students least appreciated having to get to know the internship regulations: "only" 48% awarded very good grades. The way the knowledge was communicated was also undervalued, with "only" 53% of such grades. None of the criteria received a definitely negative grade from the students, while negative grades were sporadic (2–3%). As for all the criteria, almost 90% of the students agreed that the internship supervisors performed their responsibilities very well or well.

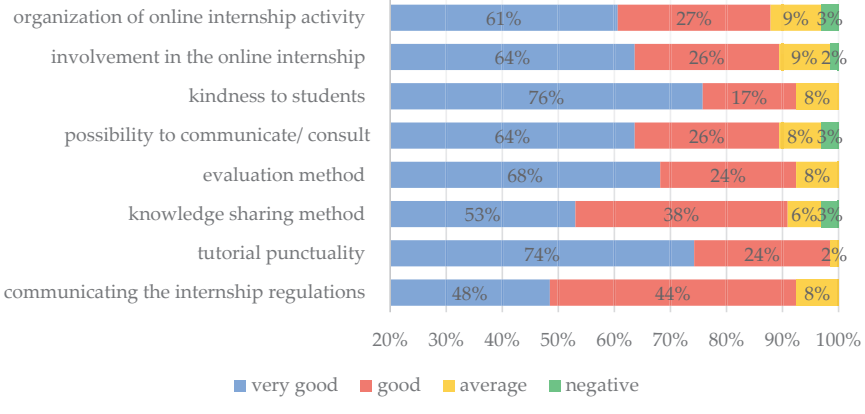

Figure 4. Evaluation of the internship supervisors by students.

5.3. Evaluation of the Skills Acquired

The questions concerning the evaluation of the skills acquired have been divided into two subgroups. The first subgroup included the questions addressing the practical skills in terms of the content-related aspects of accounting. The second subgroup of questions concerned soft skills. The responses include very high or high grades given in both question subgroups (Figures 5 and 6).

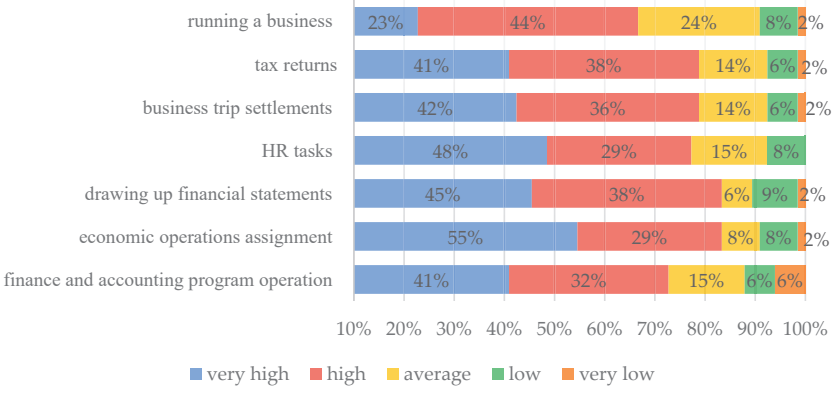

Figure 5. Evaluation of the practical skills acquired throughout e-learning internship.

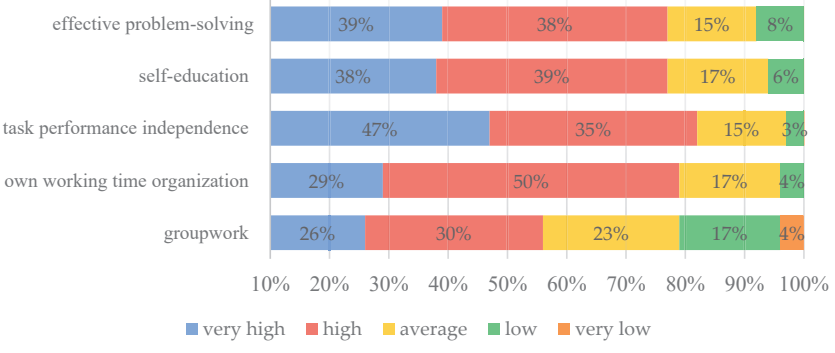

Figure 6. Evaluation of the soft skills acquired throughout the online internship.

As for practical skills, acquiring the skills for completing the economic operations scored highest; 55% of the students claimed that they had acquired a very high level of the skills, and 29% claimed a high level. The students appreciated acquiring the skills of drawing up financial statements, tax returns, finance and accounting program operation, business trip settlement, and HR tasks with slightly less optimism. A very high grade for the skills acquired was given by 41% to 48% of the respondents, and a high grade was given by 29% to 38%. Of the practical skills, the students appreciated preparation for running a business the least; very good preparation was claimed by 23% of the students, good preparation 44%, while 24% considered the preparation to be average, and 10% considered it low or very low.

As for soft skills, the students appreciated task performance independence; 47% of the interns claimed that their acquisition of this skill was very high, and 35% claimed it was high. The students least appreciated acquiring groupwork skills (26% very high and 30% high grades). The acquisition of effective problem-solving, self-education, and own working time organization skills scored similarly: 77–79% very high or high grade indications.

5.4. E-Learning Advantages and Disadvantages

In the subsequent part of the questionnaire, the respondents addressed the questions of the advantages and disadvantages of an internship given in the form of e-learning. Figure 7 presents the percentage of student responses that pointed to the key advantages of the internship method. The above criteria were evaluated by the students as a big or very big advantage of an e-learning internship.

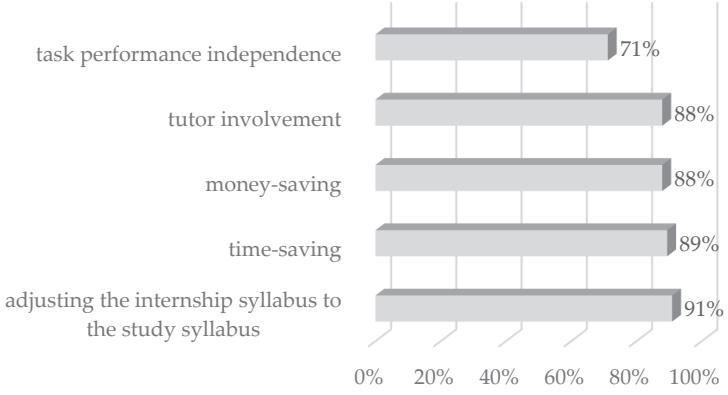

Figure 7. Online internship advantages.

According to the students, the most important advantage was adjusting the internship syllabus to the syllabus aspects of the Finance and Accounting major. In total, 91% of the respondents considered this a big or very big advantage. The other advantages are time- and money-saving due to, e.g., no need to travel to the internship destination and no costs of apartment rental (89% and 88% of the respondents, respectively). As an advantage, the students also pointed to the high involvement of the internship supervisors and the possibility of developing task performance independence (88% and 71% of the respondents, respectively, showing that it was a big or very big advantage of the internship method).

Figure 8 presents the key disadvantages of an e-learning internship that were considered either essential or very essential, according to the respondents.

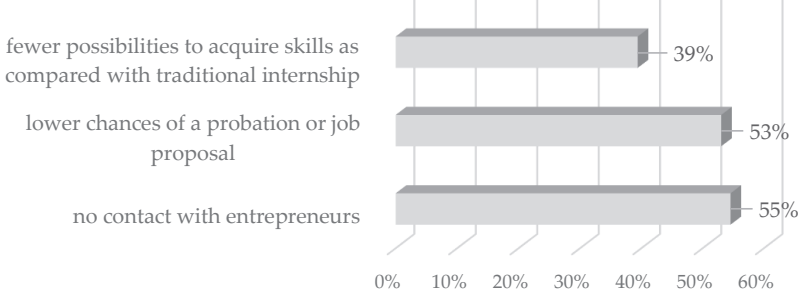

Figure 8. Online internship disadvantages.

The most frequently chosen defect in the e-learning internship was a lack of contact with entrepreneurs. In total, 55% considered this a big or very big disadvantage. Slightly fewer (53%) of the respondents indicated a lower chance of getting either a proposal of probation or a job proposal. The same number of people indicated a lack of contact with group peers. The students cited lower possibilities of acquiring practical skills as compared with traditional internships least frequently. "Only" 39% of them consider this a big or very big disadvantage.

5.5. Online Internship Problems and Difficulties Faced

The successive questions in this group concerned the difficulties faced by the students throughout the online internship using Microsoft Teams (Figure 9).

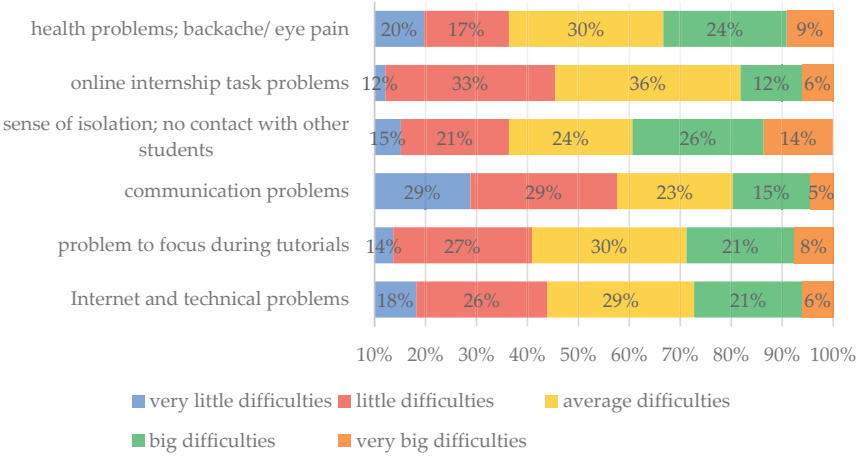

Figure 9. Online internship difficulties.

The students considered a sense of isolation and no contact with other students to be big or very big difficulties associated with online internships (14% and 26% of the respondents, respectively); 8% of the students noted very big difficulties in focusing during tutorials, and as many as 21% considered the ability to focus as presenting big difficulties. The students also suggested that e-learning triggers health problems, e.g., backache; 9% of the respondents indicated very big difficulties with health, and 24% indicated big difficulties. Technical problems also presented an obstacle for online internships (e.g., with internet connection), with 21% of the respondents indicating big difficulties, and 6% very big difficulties. Relatively fewer problems were faced by students when doing the tasks while working online; 12% of the students claimed that the online internship created big difficulties with tasks, and 6% of the respondents felt that it presented very big difficulties.

5.6. Jobs to Do as E-Learning and/or in a Traditional Learning Process

For the final research objective, the authors asked the respondents to answer the question as to which aspects of the internship can be successfully covered in the form of e-learning, and which should be delivered in a traditional form. The responses are given in Figure 10. The analysis of the responses shows that, in the opinion of the students, almost all the aspects can be covered in the form of e-learning, or that the internship format does not matter to the respondents (more than 2/3 of the respondents). An exception was learning how to assign the economic operations or using the finance and accounting program; e-learning was selected by only 26% of the students, 41% of the respondents were against it, while for 1/3, it did not matter. As for learning how to assign the economic operations with the use of a finance and accounting program, the students preferred e-learning; only 22% of the respondents were for a traditional internship, and as many as 50% supported e-learning.

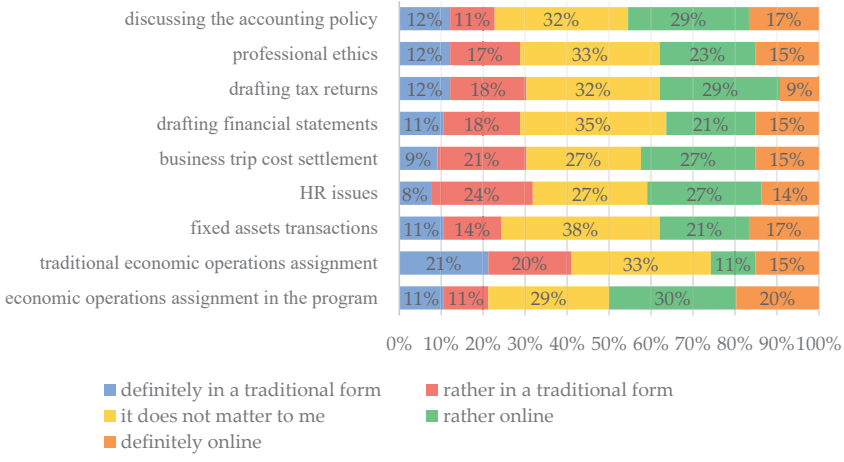

Figure 10. Issues that can be covered in the form of e-learning and/or in a traditional form.

6. Discussion

The COVID-19 pandemic has forced a change in the way knowledge is transferred and skills are shaped. In the case of e-internships for students of Finance and Accounting at the Faculty of Management of UTP, new methods of education were also introduced.

Internships conducted in a traditional way had a very general framework for their implementation, and the tasks assigned to students differed depending on the organization to which the student was assigned. Students completed an internship in real conditions, which made it possible to observe the work of an accounting office or accounting department of a company or institution in state or local government administration. The tasks performed by students as part of the internship included, first of all, getting acquainted with the accounting documentation and its circulation. The tasks entrusted included the filing in of documents, and the registration of documents in the IT system. Less often, students were entrusted with more responsible tasks, such as assigning documents, and under these circumstances, they were only of a specific type, such as purchase or sales invoices. They also did not prepare financial statements or other reports, did not close accounting periods, and did not prepare the opening balance. They could, at best, observe how such tasks were performed by other employees.

In the midst of the COVID-19 pandemic, some employers refused to accept interns majoring in Finance and Accounting. The necessity to ensure continuous education prompted the Faculty of Management at the UTP in Bydgoszcz to face the challenge of providing e-learning internships. Contrary to traditional practice, during the proposed e-internship, students had the opportunity to implement the entire project, starting from entering data about the company, through creating a chart of accounts, files of the contractor, employees' goods, etc., through the registration and accounting of economic events, and generating obligatory reports and additional reports. The scope and method of e-practice implementation, therefore, allowed the implementation of a full multi-stage project, simulating the work of an accounting office for a specific client. Compared to the traditional internship, new methods of education have been introduced, such as case studies, business simulations, multi-step projects, and computer-based learning. It was assumed that combining such an approach would engage students in the internship process and in accomplishing the learning outcomes. After the completion of the internship, the authors decided to involve the students in a study to get to know their opinions on the internship method proposed by the Faculty of Management.

The internship carried out in the form of e-learning, encompassing a case study approach, a multi-step project, and the use of finance and accounting software, was appreciated and positively verified by the students majoring in Finance and Accounting.

The results of the study coincide with the results of recent studies, mentioned in the introduction, by Mc Marthy et al. [11], Fortin et al. [10] and Grabiński et al. [3]. Almost 4/5 of the students considered the e-learning internship as either very good or good. The teachers were not previously trained in online pedagogies. The positive opinions of students about the e-internship confirm that the instructors did very well in conducting an internship in the form of e-learning, as was forced on them by the pandemic.

All three research questions were answered positively. It turned out that many more second-year students (91%) awarded a very good or good grade, as opposed to "only" 66% of the third-year students. One can assume that the discrepancies resulted from the fact that the third-year students had an earlier chance to enjoy a traditional internship with employers, and to appreciate its additional advantages. Determining the specific reasons for the discrepancies would, however, require an additional study. The e-learning internship scored higher with students living furthest from the location of the Faculty of Management. Slightly smaller differences in the assessment of internships occurred among students with a job and those without a job. A more detailed analysis (the results of which are not presented in this article) showed that students living further away and working more often than others cited benefits such as time- and cost-saving, which is in line with the results of the research carried out by Ng [50], Gavira and Omoteso [51]. It can be concluded that the students residing far away and having a job considered the subjective criteria and advantages while evaluating the internship method, rather than making an objective content-wise evaluation of the e-internship.

A detailed analysis of the responses leads to the conclusion that the positive opinions of the students were affected by the proper selection of education methods, such as case studies and multi-step projects, applied to a comprehensive solving of the simulation tasks in the IT environment. This facilitated the realization of the basic active learning assumptions via the effective engagement of the students in the internship process. The greatest advantages of the online internship listed by the students were adjusting the internship syllabus to the study syllabus and the use of the finance and accounting program, as well as the program being time-saving and money-saving, which is convergent with the results reported by Fortin et al. [10]. Some noted that interns with enterprises or accounting firms do not always have a chance to work independently with the program. After the internship, most students felt that they had acquired the skills for the practical use of the knowledge acquired from theory.

The study also shows that the internship supervisors were kind to the students, a fact that definitely created a good learning atmosphere, which is essential for the learning process and for being free from stress [53]. The engagement and the attitude of the internship supervisors were definitely factors that made the students eager to give positive feedback. This observation is consistent, inter alia, as recommended by the Jalobeanu [54]. Alongside the generally high appreciation of the internship and the advantages listed, the students did also indicate some disadvantages, especially a lack of contact with entrepreneurs and hence a lower chance of getting additional probation or a job proposal, and a sense of isolation and a lack of contact with peers, as well as problems with focusing and backaches.

7. Conclusions

To recap the results of the study, it can be said that an e-learning internship ensured continued education during the COVID-19 pandemic and helped realize the expected practical learning outcomes. It also satisfied the expectations of most students, and was appreciated by the interns. The use of a case study and multi-step projects in the computer-based learning environment strongly supports active learning, and coincides with the necessary changes in accountancy education that have been postulated for many years.

The results of the study also show that e-learning does not necessarily have to be less effective than traditional learning. The use of platforms and selecting adequate methods can activate students, support self-education and independent task performance, and, as a result, improve the effectiveness of the future education of accountants.

The authors express their hope that the conclusions drawn from the project and the results of the empirical study can facilitate the development of practical accounting tutorial syllabi in the form of e-learning, which is also necessary when facing a persisting COVID-19 pandemic and the subsequent changes taking place all around us.

Last but not least, the authors of the study note that the very positive general opinion about internships in the form of e-learning prompts the consideration of whether it is partially due to the fact that a traditional internship does not quite serve its purpose. To answer that question, it would be necessary to perform yet another study, especially considering that some of the third-year students were skeptical when evaluating the internship in the form of e-learning. While students will be able to complete the next part of their internship in a more traditional form in this or the next academic year, the authors intend to conduct another study to compare traditional practice with e-practice.

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