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Special Issue Reprint

The Use of Digital Technology for Sustainable Teaching and Learning

Edited by
Barry Lee Reynolds, Rustam Shadiev and Rui Li

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This is a reprint of articles from the Special Issue published online in the open access journal *Sustainability* (ISSN 2071-1050) (available at: www.mdpi.com/journal/sustainability/special_issues/8S45658DRZ).

For citation purposes, cite each article independently as indicated on the article page online and as indicated below:

Lastname, A.A.; Lastname, B.B. Article Title. *Journal Name* **Year**, *Volume Number*, Page Range.

ISBN 978-3-7258-2332-1 (Hbk)
ISBN 978-3-7258-2331-4 (PDF)
doi.org/10.3390/books978-3-7258-2331-4

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About the Editors

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Barry Lee Reynolds is an Associate Professor of English Language Education in the Faculty of Education at the University of Macau. He conducts interdisciplinary research in applied linguistics, second language acquisition, English language teaching, and educational technology. His work explores language problems and aims to apply research findings to practical areas like syllabus design and teaching. He focuses on vocabulary acquisition, combining intentional classroom teaching with incidental learning through media and technology.

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Preface

Sustainable teaching and learning refer to practices in which teachers equip students with the skills and strategies for engaging in lifelong independent learning that is not defined by the walls of a classroom or dependent on a knowledgeable sage. Teachers that promote sustainable learning practices have ensured students' engagement in experiential project-based learning tasks that require research, critical thinking, and collaboration. These teachers have the understanding that students should leave their classrooms appreciating that both formal and informal education is continuously being reshaped by emerging digital technologies. Students should realize that these technologies provide affordances for independent and autonomous learning practices that were not available to previous generations and have gained an understanding of how to use them to their advantages. There is a need for research that can underscore how technologies can be harnessed by students as an aid for skill attainment to become lifelong learners. This collection of articles highlights how the use of digital technology can ensure sustainable teaching and learning practices in a time when an influx of uncertainties is upon us.

Barry Lee Reynolds, Rustam Shadiev, and Rui Li
Editors

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Editorial

The Use of Digital Technology for Sustainable Teaching and Learning

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Sustainable teaching and learning encompass practices where educators equip students with the skills and strategies needed for lifelong, independent learning beyond the confinement of a traditional classroom and independent of a sole knowledgeable instructor [1]. Teachers who foster sustainable learning engage students in experiential, project-based tasks that necessitate research, critical thinking, and collaboration [2–4]. These educators understand that students should leave their classrooms with an appreciation of how both formal and informal education are continually reshaped by emerging digital technologies [5–7]. This mindset must be instilled in learners from a young age, as they are now exposed to these technologies either independently or through parental mediation [8–10].

As state-of-the-art innovative educational technologies continue to emerge at a rapid pace, their affordances have offered a vast array of opportunities for sustainable learning and instruction [11]. Some of these emerging digital technologies include mobile tools [12–14], social media [15,16], virtual and augmented reality [17], online collaborative tools [18,19], and artificial intelligence [20–22], among others.

Students should recognize that these technologies offer opportunities for independent and autonomous learning practices that were unavailable to previous generations. They need to understand how to leverage these tools to their advantage [3,7,11,23]. There is a pressing need for research that demonstrates how technologies can be harnessed to help students acquire skills for lifelong learning. Thus, this Special Issue aims to highlight how digital technology can ensure sustainable teaching and learning practices in an era marked by uncertainties.

The objective of this Special Issue was to compile pioneering theoretical work and original applications related to the use of digital technology in sustainable teaching and learning. The focus was on learning models and theories that illuminate this crucial dimension, exploring their applications across various educational settings and demonstrating their effectiveness through systematic or empirical data.

For this Special Issue, we initially received 46 submissions from various countries and territories. These submissions were rigorously reviewed by well-known international experts in the field, with each article reviewed by at least three reviewers. After several rounds of thorough evaluation, we selected the twelve best articles that represent the highest quality, suitable for a prestigious journal like *Sustainability*. These selected articles offer original scientific contributions in the form of theoretical and experimental research, as well as case studies that provide new perspectives on sustainable teaching and learning using digital technology.

This Special Issue comprises the following twelve articles:

"A Meta-Analysis and Systematic Review of the Effect of Chatbot Technology Use in Sustainable Education" by Xinjie Deng and Zhonggen Yu. The authors investigated the

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Citation: Shadiev, R.; Reynolds, B.L.; Li, R. The Use of Digital Technology for Sustainable Teaching and Learning. *Sustainability* **2024**, *16*, 5353. https://doi.org/10.3390/su16135353

Received: 16 June 2024
Accepted: 20 June 2024
Published: 24 June 2024

effect of chatbot-assisted learning on various components and examined how different moderator variables influenced its effectiveness. To achieve this, they conducted a meta-analysis of 32 empirical studies involving 2201 participants, published between 2010 and 2022.

"A Study on Teachers' Continuance Intention to Use Technology in English Instruction in Western China Junior Secondary Schools" by Yi Xie, Azzeddine Boudouaia, Jinfen Xu, Abdo Hasan AL-Qadri, Asma Khattala, Yan Li and Ya Min Aung. The authors investigated the factors influencing the continuance intention to use technology among English teachers in China. They examined the direct effects of help seeking, interest, effort regulation, growth mindset, facilitating conditions, perceived usefulness, and perceived ease of use on continuance intention. Additionally, they explored the indirect effects of these factors on continuance intention through self-efficacy. The study sample included 459 English language teachers from junior secondary schools in various regions of Western China. A questionnaire encompassing these variables was used and validated through exploratory factor analysis and confirmatory factor analysis.

"Applications of Reciprocal Teaching in Flipped Classroom to Facilitate High Level of Cognition for Sustainable Learning Practices" by Wu-Yuin Hwang, Tsu-Hsien Wu and Rustam Shadiev. The authors conducted two consecutive studies to enhance students' opportunities to cultivate and develop high-level cognitive abilities for sustainable learning practices. In both studies, a flipped classroom approach was integrated into the project-based engineering education curriculum. Twelve junior graduate students majoring in Electrical Engineering participated in Study 1, while ten participated in Study 2. They all attended the Signal Processing of Power Quality Disturbances class and practiced their skills in a computer lab using LabView software. In Study 2, the reciprocal teaching method was introduced to help students manage cognitive load and develop advanced cognitive skills.

"A Bibliometric Analysis of Trending Mobile Teaching and Learning Research from the Social Sciences" by Chun Wai Fan, Jiayi Lin and Barry Lee Reynolds. The authors conducted a bibliometric analysis of trending mobile teaching and learning research in social sciences. They utilized two science mapping tools, CiteSpace 6.3.R3 and VOSviewer 1.6.18, to detect and visualize emerging trends in the mobile learning literature. A total of 528 mobile learning articles, published between 2003 and 2021 in 21 international educational technology journals indexed in the SSCI database, were retrieved for analysis and reviewed by the researchers.

"A Bibliometric Analysis of Augmented Reality in Language Learning" by Wenhe Min and Zhonggen Yu. The authors analyzed the use of AR tools in language learning contexts using the bibliometric tools VOSviewer 1.6.18 and CitNetExplorer 1.0.0., employing both qualitative and quantitative research methods. They identified the top ten authors, sources, countries, and organizations using VOSviewer and established citation networks using CitNetExplorer.

"Exploring Undergraduate Students' Digital Multitasking in Class: An Empirical Study in China" by Qikai Wang, Fei Sun, Xiaochen Wang and Yang Gao. To gain further insights into the impact of smartphone-induced digital multitasking on the education process in higher education, the authors surveyed 519 students from a Chinese university in their exploratory descriptive study to investigate the magnitude of students' digital multitasking, the motivation behind it, and their beliefs about reducing phone use.

"A Study on Technology Use for Sustainable Graduate Education Internationalization at Home: Chinese Teachers' Experiences and Perspectives" by Qian Xu and Azzeddine Boudouaia. The authors explored the use of technology in promoting the sustainable internationalization of graduate education in China through teachers' experiences and perspectives. They assessed how various aspects of technology-based education influence the internationalization of graduate education. The study involved 806 teachers from different universities across China, and data were collected using a questionnaire.

"Teachers' Acceptance of Online Teaching and Emotional Labor in the EFL Context" by Renzhong Peng, Qiqin Hu and Bochra Kouider. The authors investigated the relationship between English as a Foreign Language (EFL) teachers' acceptance of online teaching and their emotional labor in online teaching using the Technology Acceptance Model (TAM). A questionnaire was distributed to 338 EFL teachers from 19 middle schools and 24 high schools in China, and 10 teachers were interviewed. Through a series of data analyses, the authors developed and tested a structural relationship model that integrates acceptance of online teaching with online teaching emotional labor strategies.

"Presence and Flow as Moderators in XR-Based Sustainability Education" by Miriam Mulders and Kristian Heinrich Träg. The authors explored the role of presence and flow as moderators in XR-based sustainability education through a mixed-methods study of a VR- and AR-based learning application on biodiversity developed by Greenpeace. A total of 156 students tested the application, which focused on the Amazon rainforest, and rated its efficacy in terms of its effects on knowledge, interest, and attitude. Pre- and post-questionnaires, as well as focus groups, were used to uncover within-subject effects.

"Application of Business Simulation Games in Flipped Classrooms to Facilitate Student Engagement and Higher-Order Thinking Skills for Sustainable Learning Practices" by Ching-Yun Hsu and Ting-Ting Wu. The authors investigated the effectiveness of incorporating business simulation games with project-based learning in a flipped classroom setting. This approach was applied in a university cross-border e-commerce course to help students acquire 21st-century skills, such as higher-order thinking, in a rapidly changing educational landscape. A quasi-experimental method was used, involving 60 university students from Zhejiang Province, China. Participants completed an online questionnaire assessing their learning engagement across cognitive, emotional, and behavioral dimensions, as well as their higher-order thinking skills, including problem solving, critical thinking, and creativity.

"Constructing Sustainable Learning Ecology to Overcome Burnout of Teachers: Perspective of Organizational Identity and Locus of Control" by Zehra Altinay and Batuhan Bicentürk. The authors examined how organizational identity, locus of control, and their inter-relationships affect teacher burnout. Data were collected from 105 teachers using a quantitative survey. The Maslach Burnout Inventory measured three dimensions of burnout: emotional exhaustion, depersonalization, and personal accomplishment. Locus of control was assessed using Rotter's scale. Organizational identity was measured with the Multiple Organizational Identification Scale, which assesses personal self-esteem, emotional professional identity, evaluative identification, self-classification, and team factors.

"Cultural Heritage for Sustainable Education Amidst Digitalisation" by Yianna Orphanidou, Leonidas Efthymiou and George Panayiotou. Given the role of integrating cultural heritage in education to enhance critical thinking, experiential learning, cross-cultural collaboration, and the overall quality of learning experiences, the authors conducted a study of mixed methods (questionnaires and interviews) in three European countries to examine digital and cultural heritage competencies among young learners. This investigation is particularly important in light of the increasing adoption of digital technology, the varying levels of digital literacy, high student dropout rates in some European Union countries, and the decline in cultural heritage awareness among young learners.

Conflicts of Interest: The authors declare no conflict of interest.

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Systematic Review

A Meta-Analysis and Systematic Review of the Effect of Chatbot Technology Use in Sustainable Education

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Abstract: The development of artificial intelligence in recent years has promoted the use of chatbot technology in sustainable education. Many studies examined the effect of chatbots on learning outcomes. However, scant studies summarized the effectiveness of chatbots in education. The aim of the study is to investigate the effect of chatbot-assisted learning on various components and how different moderator variables influenced the effectiveness. This study, through a meta-analysis, reviewed 32 empirical studies with 2201 participants published between 2010 and 2022. The results showed that chatbot technology exerted a medium-to-high effect on overall learning outcomes regardless of moderator variables, i.e., intervention duration, chatbot roles, and learning content. In terms of learning components, chatbots could significantly improve explicit reasoning, learning achievement, knowledge retention, and learning interest despite negative findings in critical thinking, learning engagement, and motivation. Future research could expand chatbot research by including different learning components.

Keywords: chatbot technology; meta-analysis; learning outcomes; chatbot-assisted learning; sustainable education

Citation: Deng, X.; Yu, Z. A Meta-Analysis and Systematic Review of the Effect of Chatbot Technology Use in Sustainable Education. *Sustainability* **2023**, *15*, 2940. https://doi.org/10.3390/su15042940

Academic Editors: Barry Lee Reynolds, Rustam Shadiev and Rui Li

Received: 29 December 2022
Revised: 3 February 2023
Accepted: 3 February 2023
Published: 6 February 2023

1. Introduction

As the popularity of information technologies grows, chatbots have caught the increasing attention of stakeholders in the educational context. A chatbot is a conversational program that can process input and accordingly provide information through verbal or written interactions [1]. Researchers and practitioners could even design chatbots by themselves based on Dialogflow (e.g., [2,3]). Dialogflow is a natural language understanding platform integrating conversational interfaces into various devices, applications, and bots [4]. During the post-pandemic period when online learning still plays an important role, chatbot integration alleviates teachers' workload to provide individual support for students with limited resources and personalizes students' pace of learning [5]. Unlike teachers, educational chatbots could answer students' questions anytime and anywhere. They have the ability to handle several questions at the same time.

However, the use of chatbot technology also brings challenges. They can be described as issues in ethics, evaluation, users' attitudes, programming, supervision, and maintenance [6]. Problems have also included technological limitations and training side effects [7]. Simultaneously, there comes another issue. The novelty effect may appear when students are introduced to new technology. The improvement of learning outcomes might result from students' newness to chatbot technology [8]. Given the benefits and concerns of educational chatbot use, many studies have measured the effectiveness of chatbots but have obtained inconsistent findings.

Although some review studies focused on chatbot-based education, few of them synthesized previous studies to identify the overall effect of chatbots. Recent review articles either provided basic information on chatbot research through visualization (e.g., [9]), or summarized chatbot roles, evaluation methods, application fields, affordances, and

challenges through content analysis (Table 1). In terms of the effectiveness of chatbots, there were two meta-analyses calculating the overall effect size of chatbots on language learning. Lee and Hwang [10] limited their research to English as a foreign language education, and Bibauw et al. [11] also used language learning as the research topic.

Table 1. The research focus of relevant review studies.

N	Focus	Relevant Review Study
1	Research authors, journals, and countries	Hwang and Chang [9]
2	Advantages and challenges of chatbot use	Huang et al. [1], Okonkwo, and Ade-Ibijola [6], Perez et al. [7]
3	Chatbot roles	Kuhail et al. [9]
4	Evaluation methods	Perez et al. [4], Kuhail et al. [12]
5	Application fields	Okonkwo and Ade-Ibijola [6], Hwang and Chang [9], Kuhail et al. [12]
6	The overall effect of chatbots on language learning	Lee & Hwang [10], Bibauw et al. [11]
7	The overall effect of chatbots on education	This study

However, some previous studies only investigated a particular context. Lee and Hwang [10] focused on the effect of chatbots in the Korean context. In recent years, the Chinese Ministry of Education has been advocating technology-enhanced education. Chatbots could improve Chinese students' thinking ability and facilitate interactive learning [13]. The meta-analysis of chatbot technology in education across the world remains sparse. This study thus aims to examine the effect of chatbot use on various components and whether the effectiveness would be influenced by different variables. This study would shed light on the effect of chatbot-assisted learning not only in China but also in other countries and regions. It could also provide a reference for sustainable education and developing certain abilities and affective domains.

2. Literature Review

Chatbots perform three roles in education, i.e., teaching assistants, learning partners, and personal tutors. Inspired by Li and Yu [14], the authors summarized the role of chatbots in Figure 1. Operating as a teaching assistant, the chatbot mechanism provided professional knowledge and formative feedback [15] and scaffolded students' online learning [16]. Chatbots, as learning partners, chatted and interacted with students through either texts or voices. The tutorial role required chatbots to offer questions and answers, guided students to start their learning [17], and give quizzes [18]. The three educational roles of chatbots are intertwined with each other, contributing to effective teaching and learning [14,19]. Given the function of chatbots, it is most likely that chatbot-based education would positively and significantly influence critical thinking, explicit reasoning, learning achievement, knowledge retention, engagement, motivation, and interest.

2.1. Critical Thinking

Critical thinking refers to the thinking process of forming self-regulatory and reflective judgments which could determine one's beliefs and behaviors [20]. As one of the 21st-century skills, critical thinking has become increasingly pivotal in education [21]. Students are encouraged to express their viewpoints based on critical analysis and reasoning [22]. Therefore, recent years have witnessed many studies on the cultivation of critical thinking, especially with the assistance of artificial intelligence and information communication technology tools [23]. The use of emerging technologies such as chatbot systems could guide and inspire students to think over and make judgments, thus gradually developing the habit of critical thinking. The artificial intelligence-integrated chatbot was proved effective to enhance students' thinking ability and expectations [13]. Accordingly, the authors proposed the following null hypothesis.

H1. *The use of chatbot technology could not significantly improve critical thinking at the 0.05 level.*

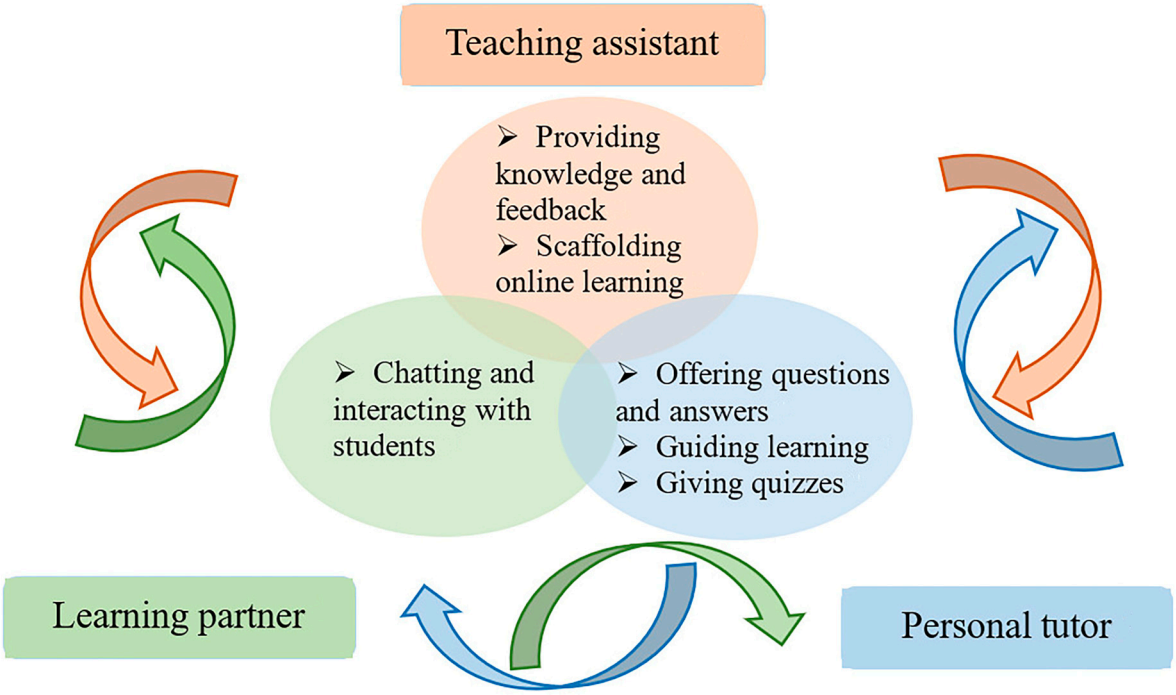

Figure 1. Three roles of chatbots in education.

2.2. Explicit Reasoning

Explicit reasoning is derived from the academically productive talk framework which emphasizes social interaction and reasoned participation [24]. The explicitness of reasoning is an important feature of students' effective communication. Peer dialogues should involve learning community, accurate knowledge, and rigorous thinking [25]. Specifically, students are expected to learn from each other, explicate their reasoning, and construct logical arguments in open-ended discussions and collaborative activities. It was found that chatbots could trigger and scaffold students' discussions, stimulating explicit reasoning processes [26]. Moreover, explicit reasoning could increase collaboration practices, improve learning outcomes, and promote conceptual knowledge acquisition [27]. The authors thus raised the following null hypothesis.

H2. *The use of chatbot technology could not significantly improve explicit reasoning at the 0.05 level.*

2.3. Learning Achievement and Knowledge Retention

Learning achievement is the measurement of students' academic success in a given period of time [28]. Most of the existing research on chatbot-based learning investigated learning achievement, including gains in second language speaking proficiency [29], aircraft engine maintenance test scores [30], vaccine knowledge scores [31], numerical system conversion test results [18], and transfer ability [32]. Through the pretest–posttest design, Ghanaian undergraduate students in the chatbot group better performed academically than those interacting with instructors [33]. However, chatbots may not significantly improve secondary school students' academic performance [3].

Knowledge retention, also known as learning retention, is defined as the ability to capture information and transfer it from short-term to long-term memory [34]. Many researchers mainly examined this ability via retention tests, e.g., delayed posttests for vocabulary knowledge [35] and multiple-choice question tests for programming knowledge [32]. The dynamic assessment of chatbots was effective in enhancing vocabulary retention and providing detailed information about personal learning [2]. The chatbot also facilitated the retention of Python programming knowledge [32]. Therefore, the authors proposed the following null hypotheses.

H3. *The use of chatbot technology could not significantly improve learning achievement at the 0.05 level*.

H4. *The use of chatbot technology could not significantly improve knowledge retention at the 0.05 level*.

2.4. Learners' Engagement, Motivation, and Interest

Many previous studies have examined the effect of chatbots on students' engagement. Engagement is the extent to which students actively involve or participate in learning activities [36]. A narrative-based learning system equipped with chatbot feedback significantly improved users' engagement [37]. Likewise, a mobile chatbot-based learning approach enabled nursing students to believe that chatbots could promote their learning engagement [31]. However, the interaction with chatbots failed to make a statistically significant difference in engagement in the extensive reading activity [38]. Considering inconsistent findings, the following null hypothesis was determined.

H5. *The use of chatbot technology could not significantly enhance learning engagement at the 0.05 level*.

Researchers also investigated the effect of chatbots on learning motivation. Motivation, unlike engagement, refers to the possibility of engaging in learning tasks and maintaining learning behavior [39]. Essentially, engagement highlighted action, while motivation emphasized intent [40]. Motivation can be categorized into intrinsic and extrinsic motivations [41]. Intrinsic motivation focuses on learners' inner satisfaction, whereas extrinsic motivation is defined as the behavior for external and separable results [42]. The voice-based chatbots positively influenced middle school students' motivation [43]. Furthermore, chatbot-assisted instructional videos and micro-learning systems could also effectively promote intrinsic motivation [18,44]. Thus, the authors presented the following null hypothesis.

H6. *The use of chatbot technology could not significantly enhance learning motivation at the 0.05 level*.

Previous studies also focused on the effect of chatbot technology on learning interest. Interest indicates the individual readiness or predisposition to engage in a given learning task with effort [45]. Chatbots improved Korean students' interest in foreign language learning [43]. Similarly, nursing college students using chatbots experienced a higher level of learning interest than their peers in the control group [46]. Chatbots also increased college students' interest in English vocabulary learning [47]. The authors thus raised the following null hypothesis.

H7. *The use of chatbot technology could not significantly enhance learning interest at the 0.05 level*.

2.5. Intervention Duration

Previous studies experimented with different durations and obtained different results. The study [18] whose intervention lasted for only 40 min found no significant differences in learning performance between the chatbot and control groups. Fifteen instructional sessions carried out over three weeks facilitated students' comprehension of English adjectival constructions but failed to help learners generate prepositional constructions [48]. However, speaking test scores in the experimental group were significantly higher than those of the control group after the four-month experiment [49]. In the field of educational technology, some meta-analyses have investigated the influence of implementation duration. For example, Chen et al. [50] examined the effects of mobile devices on language learning across different intervention durations. The authors therefore developed the following null hypothesis.

H8. *Intervention duration could not influence the effect of chatbot-assisted learning*.

2.6. Chatbot Roles

Researchers assigned different roles to chatbots in their experiments. University students created conversations with the chatbot Elbot ranging from school life to movies. After eight weeks, the experimental group better acquired vocabulary knowledge than the control group [47]. The AsasaraBot, acting as a tutor, provided questions, encouragement, and interactions, aiming to support students' language learning [15]. However, the experimental group performed worse than students equipped with other technological tools such as Google Forms. Using chatbots as teaching assistants, learners significantly outperformed those in traditional classroom settings in terms of projected-based learning performance [51]. The meta-analysis of robot-assisted language learning [52] examined the influence of robot roles on the effectiveness of social robots. Therefore, the authors formulated the following null hypothesis.

H9. *Chatbot roles could not influence the effect of chatbot-assisted learning*.

2.7. Learning Content

Chatbot technology has been applied to many disciplines; thus, participants' learning content has varied among studies. In nursing education, students used chatbot systems to learn courses about the physical examination, effectively enhancing students' academic performance [53]. The LINE Bot used in military science could provide procedures for engine fan module decomposition, which improved trainee performance and reduced training costs [30]. In the field of second language learning, students interacted with chatbots to practice their speaking skills [29]. However, the chatbot was ineffective when students developed computing knowledge, e.g., conversion of numerical systems [18]. The authors thus proposed the following null hypothesis.

H10. *Learning content could not influence the effect of chatbot-assisted learning*.

3. Materials and Methods

The researchers conducted a meta-analysis by collecting studies, coding included studies, and calculating the effect sizes. They strictly followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines [54]. It was not necessary to pre-register this systematic review in a designated public repository such as Prospero since this study did not involve the health of animals and human beings.

3.1. Literature Search

At the beginning, the authors determined search keywords by clustering the literature. They obtained 741 results in the Web of Science by keying in the research themes "chatbot" AND "learning". The results were output in the form of plain texts and imported into VOSviewer. The type of analysis was co-occurrence, and the unit of analysis was all keywords. The minimum number of occurrences of a keyword was set at three. Of the 2295 keywords, 217 met the threshold and were categorized into 11 clusters (Figure 2). The researchers obtained the top 10 frequently-occurring keywords: chatbot (N = 340), artificial intelligence (N = 96), machine learning (N = 90), chatbots (N = 89), deep learning (N = 81), natural language processing (N = 73), conversational agents (N = 36), conversational agent (N = 28), education (N = 24), and technology (N = 23).

The authors obtained 2322 studies from online databases on 3 September 2022. The major databases included Web of Science, Wiley Online Library, Springer Link, Taylor & Francis Online, Elsevier ScienceDirect, and Google Scholar (Figure 3). Considering the above findings of bibliometric analysis and the aim of this study, the researchers retrieved 228 results by entering the topic terms: (chatbot OR "conversational agent") AND (education OR learn* OR teach*) AND ("control group" OR experim* OR experient*) from Web of Science Core Collection. They also obtained 56 results from Wiley and 54 results from Taylor & Francis by keying in "chatbot OR conversational agent" AND "education

OR learning OR teaching OR control OR experiment" in the Abstract. Researchers obtained 20 records from Springer and 1860 results from Google Scholar by entering in "chatbot" in *where the title contains* AND "control group" in *with the exact phrase* AND "education OR learn OR teach" in *with at least one of the words*. Researchers also retrieved 104 studies by keying in "chatbot OR conversational agent" in the Title AND "education OR learning OR teaching OR control OR experiment" in Title, abstract, keywords from Elsevier.

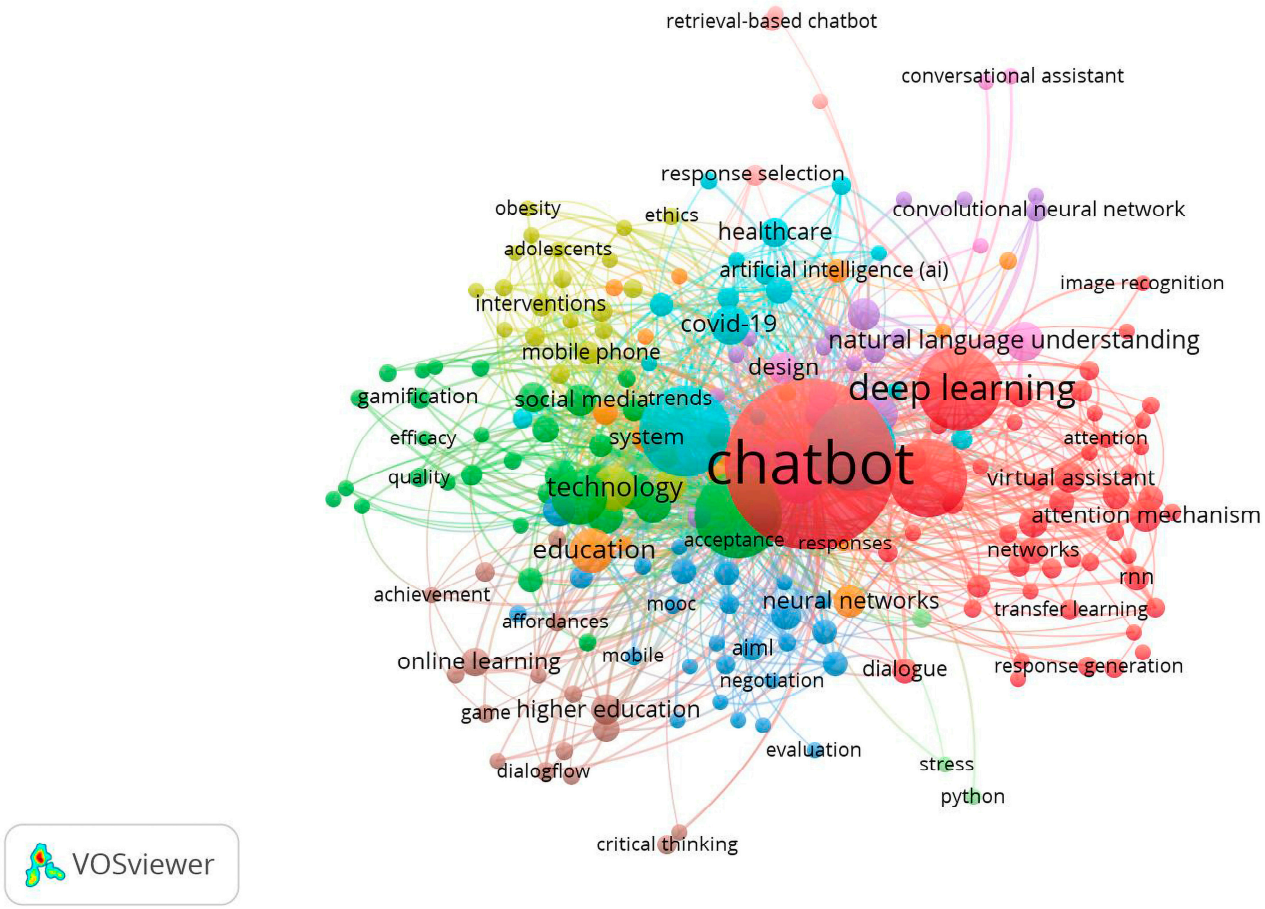

Figure 2. Clustering keywords related to chatbot-assisted learning.

3.2. Inclusion and Exclusion Criteria

The researchers followed the inclusion and exclusion criteria to select the literature. The identified studies should (1) determine the effect of chatbot technology on educational outcomes; (2) include the experimental group that adopted chatbot-based learning and the control group that used traditional learning approaches; (3) report sufficient statistics, i.e., sample sizes, means, and standard deviations, to calculate effect sizes; (4) ensure homogeneity between the control group and the experimental group, i.e., students' prior learning outcomes should be equivalent; and (5) be written in English and be published from 2010 to 2022. The studies were excluded if they (1) were irrelevant to educational use of chatbots; (2) lacked control groups; (3) did not provide adequate information for effect-size calculations; and (4) were not written in an acceptable English language.

Based on the inclusion and exclusion criteria, the researchers included 25 studies in this meta-analysis after the first round of screening. To avoid the case that some studies may be excluded by mistake, the researchers conducted another two rounds of screening. They found that four studies, which met all the inclusion criteria, were accidentally excluded in the first round of screening. Therefore, given three studies from previous reviews, there were altogether 32 studies included in this meta-analysis (Figure 3).

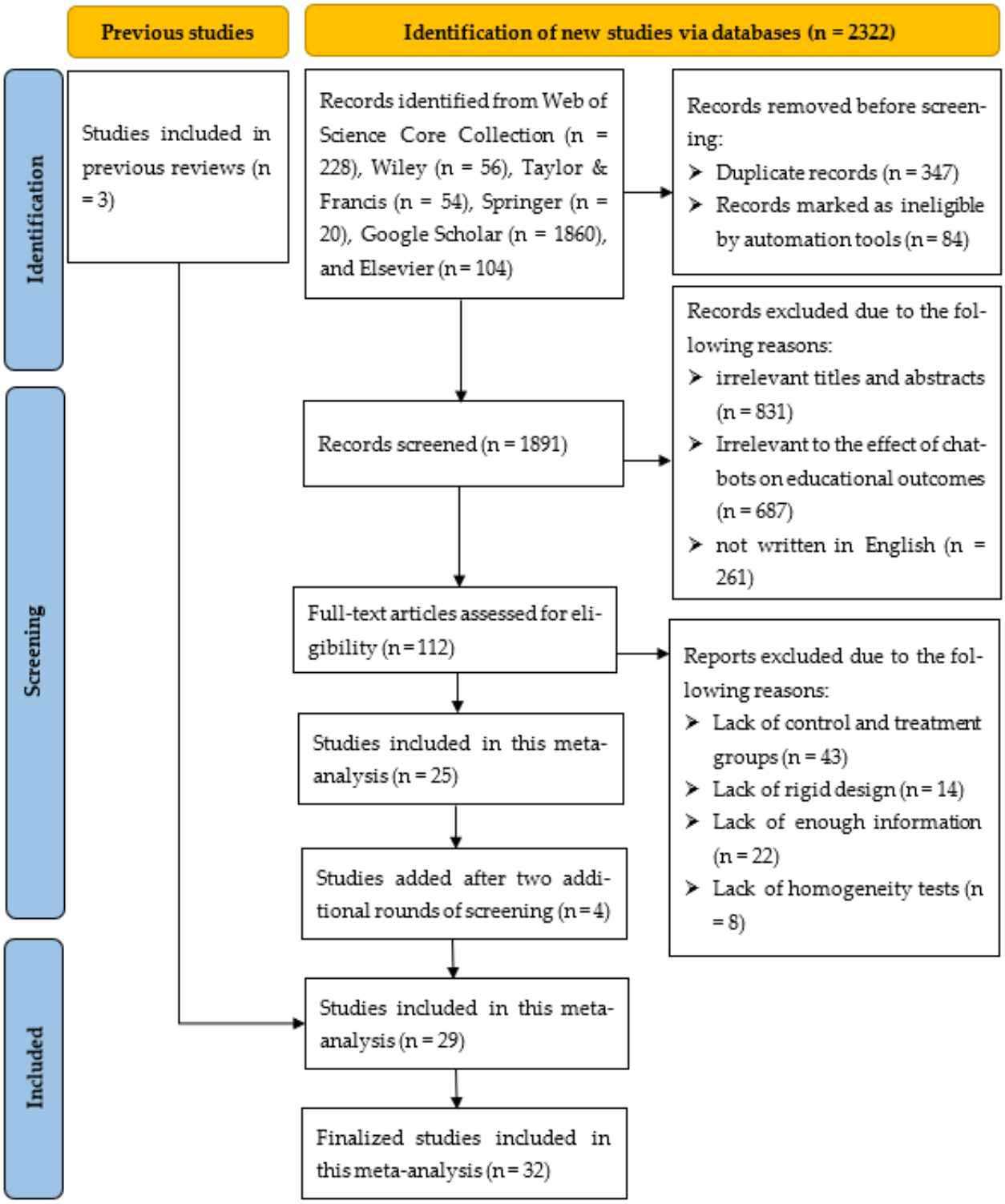

Figure 3. The flowchart of study inclusion.

3.3. Coding Procedures

The researchers developed a coding scheme consisting of comparable features of chatbot-based learning. First, basic information included the author's last name, publication year, and sample sizes. Second, regarding the instruction duration, the researchers at first coded it as a continuous variable. However, inspired by Chen et al. [50], the researchers decided to recode this variable as a categorical one for further analysis. Considering the data characteristics, the researchers divided the duration variable into five categories:

less than 1 week, less than 5 weeks, less than 10 weeks, more than 10 weeks, and not specified. Third, the chatbot role variable was classified into teaching assistants, tutors, and learning partners. Fourth, the researchers categorized the educational outcomes into critical thinking, explicit reasoning, learning achievement, knowledge retention, learning engagement, learning motivation, and learning interest. The defining terms of the above categories were, respectively, critical thinking scores [53], the frequency of explicit position and explicit argument [24], test scores [29], retention test scores [2], engagement scale scores [38], motivation questionnaire scores [18], and interest scale scores [47]. Fifth, in terms of learning content, the researchers divided it into five categories, i.e., computer science, instructional technology, language, medicine, and others. Table 2 shows the detailed information of included studies.

Table 2. The coding results of included studies.

N	Author (Year)	Sample Size (Experimental Group/Control Group)	Instruction Duration	Chatbot Role	Learning Content	Educational Outcomes
1	Tegos and Demetriadis (2017) [26]	72 (38/34)	40 min	Tutor	Computer science	Explicit reasoning and learning achievement
2	Winkler et al. (2020) [32]	72 (37/35)	30 min	Tutor	Computer science	Learning achievement and retention
3	Song and Kim (2021) [16]	56 (27/29)	15 weeks	Partner	Instructional technology	Learning achievement
4	Chang et al. (2022) [53]	32 (16/16)	100 min	Tutor	Medicine	Critical thinking and learning achievement
5	Tegos et al. (2015) [55]	43 (21/22)	70 min	Tutor	Computer science	Explicit reasoning and learning achievement
6	Tegos et al. (2016) [24]	64 (32/32)	40 min	Tutor	Computer science	Explicit reasoning and learning achievement
7	Fidan and Gencel (2022) [44]	94 (54/40)	4 weeks	Tutor	Instructional technology	Learning motivation and achievement
8	H. L. Chen et al. (2020) [17]	58 (19/29)	4 weeks	Tutor	Language	Learning achievement and retention
9	Yuan et al. (2021) [30]	40 (20/20)	2–3 weeks	Tutor	Others	Learning achievement
10	Mageira et al. (2022) [15]	35 (18/17)	2 days	Tutor	Language	Learning achievement
11	Vazquez-Cano et al. (2021) [56]	103 (52/51)	2 weeks	Teaching assistant	Language	Learning achievement
12	Chang, Hwang, et al. (2022) [31]	36 (18/18)	100 min	Tutor	Medicine	Learning achievement
13	Yin et al. (2021) [18]	99 (51/48)	40 min	Tutor	Computer science	Learning motivation and achievement
14	Lee et al. (2022) [57]	38 (18/20)	200 min	Tutor	Medicine	Learning motivation and achievement
15	Ruan et al. (2020) [37]	36 (18/18)	25.75 min	Tutor	Others	Learning engagement and achievement
16	Kim (2018) [47]	47 (24/23)	8 weeks	Partner	Language	Learning interest, motivation, and achievement

Table 2. *Cont.*

N	Author (Year)	Sample Size (Experimental Group/Control Group)	Instruction Duration	Chatbot Role	Learning Content	Educational Outcomes
17	Han (2020) [43]	44 (22/22)	10 weeks	Partner	Language	Learning interest, motivation, and achievement
18	Kim (2018) [58]	46 (24/22)	16 weeks	Partner	Language	Learning achievement
19	Kumar (2021) [51]	60 (30/30)	10 weeks	Teaching assistant	Instructional technology	Learning achievement
20	Kim et al. (2021) [59]	75 (37/38)	1 semester	Partner	Language	Learning achievement
21	Jeon (2021) [2]	35 (18/17)	25 min	Tutor	Language	Learning achievement and retention
22	Farah et al. (2022) [60]	20 (11/9)	30 min	Tutor	Computer science	Learning engagement and achievement
23	Goda et al. (2014) [61]	63 (31/32)	30 min	Partner	Language	Critical thinking and learning achievement
		67 (32/35)	30 min	Partner	Language	Critical thinking
24	Wambsganss et al. (2021) [62]	55 (31/24)	15 min	Teaching assistant	Language	Learning achievement
25	Kim (2022) [48]	64 (32/32)	3 weeks	Tutor	Language	Learning achievement and retention
26	Dizon (2020) [29]	28 (13/15)	10 weeks	Tutor	Language	Learning achievement
27	Abbasi et al. (2019) [63]	110 (55/55)	Not available	Teaching assistant	Computer science	Learning achievement
28	Abbasi and Kazi (2014) [64]	72 (36/36)	Not available	Teaching assistant	Computer science	Learning achievement
29	Lin and Chang (2020) [65]	357 (167/190)	2 weeks	Teaching assistant	Language	Learning achievement
30	Liu et al. (2022) [38]	62 (41/21)	6 weeks	Partner	Language	Learning engagement and interest
31	Hsu et al. (2021) [49]	48 (24/24)	4 months	Tutor	Language	Learning achievement
32	Na-Young (2019) [66]	70 (36/34)	10 sessions	Partner	Language	Learning achievement

3.4. Data Analysis

This study used Stata MP/14.0 to carry out the meta-analysis. Cohen's d, responsible for the measurement of effect sizes, is calculated by dividing the mean difference between the experimental and control groups by the pooled standard deviation [67]. The calculation formula is as follows. The researchers calculated 76 effect sizes with a total sample size of 2201 in 32 identified studies.

$$\text{Cohen's } d = \frac{M_E - M_C}{\sqrt{\frac{(N_E - 1)\ S_E^2 + (N_C - 1)\ S_C^2}{(N_E - 1) + (N_C - 1)}}} \quad (1)$$

The researchers examined publication bias using both visual and mathematical tests, including the funnel plot, Begg's test, and Egger's test. Through the shape of the funnel plot, researchers could preliminarily assess publication bias. The dots will be symmetrically

distributed along the no-effect line if there is no publication bias, while the plot will be asymmetric if there is a presence of publication bias. Statistically, both Begg's and Egger's tests reported *p*-value, which determines the presence or absence of publication bias.

The researchers also measured heterogeneity using I^2 test and conducted sensitivity analysis. The heterogeneity will be considered low if I^2 is less than 25%, moderate if I^2 falls between 25% and 75%, and substantial if I^2 is greater than 75% [68]. Generally, heterogeneity is significant when I^2 is larger than 50% and a random effects model should be adopted accordingly. Otherwise, heterogeneity is insignificant, and the fixed effects model should be used.

4. Results

4.1. Analyses of Publication Bias

Both Egger's and Begg's tests (Table 3) checked whether the identified studies were influenced by publication bias. The results of both tests indicated the absence of publication bias in critical thinking ($t = 14.17$, $p = 0.111$; $z = 1.47$, $p = 0.142$), explicit reasoning ($t = 1.90$, $p = 0.424$; $z = 1.32$, $p = 0.188$), learning achievement ($t = 4.36$, $p = 0.083$; $z = 0.53$, $p = 0.598$), knowledge retention ($t = 10.18$, $p = 0.061$; $z = 1.47$, $p = 0.142$), learning engagement ($t = -0.14$, $p = 0.946$; $z = 1.35$, $p = 0.176$), and learning motivation ($t = 8.17$, $p = 0.216$; $z = 1.23$, $p = 0.217$). The funnel plot also confirmed test results (Figure 4). Using learning motivation as an example, the funnel graph was obviously symmetrical, revealing no publication bias. However, Begg's test showed a presence of publication bias in learning interest ($z = 2.04$, $p = 0.042$), which was different from the result of Egger's test ($t = 15.30$, $p = 0.056$).

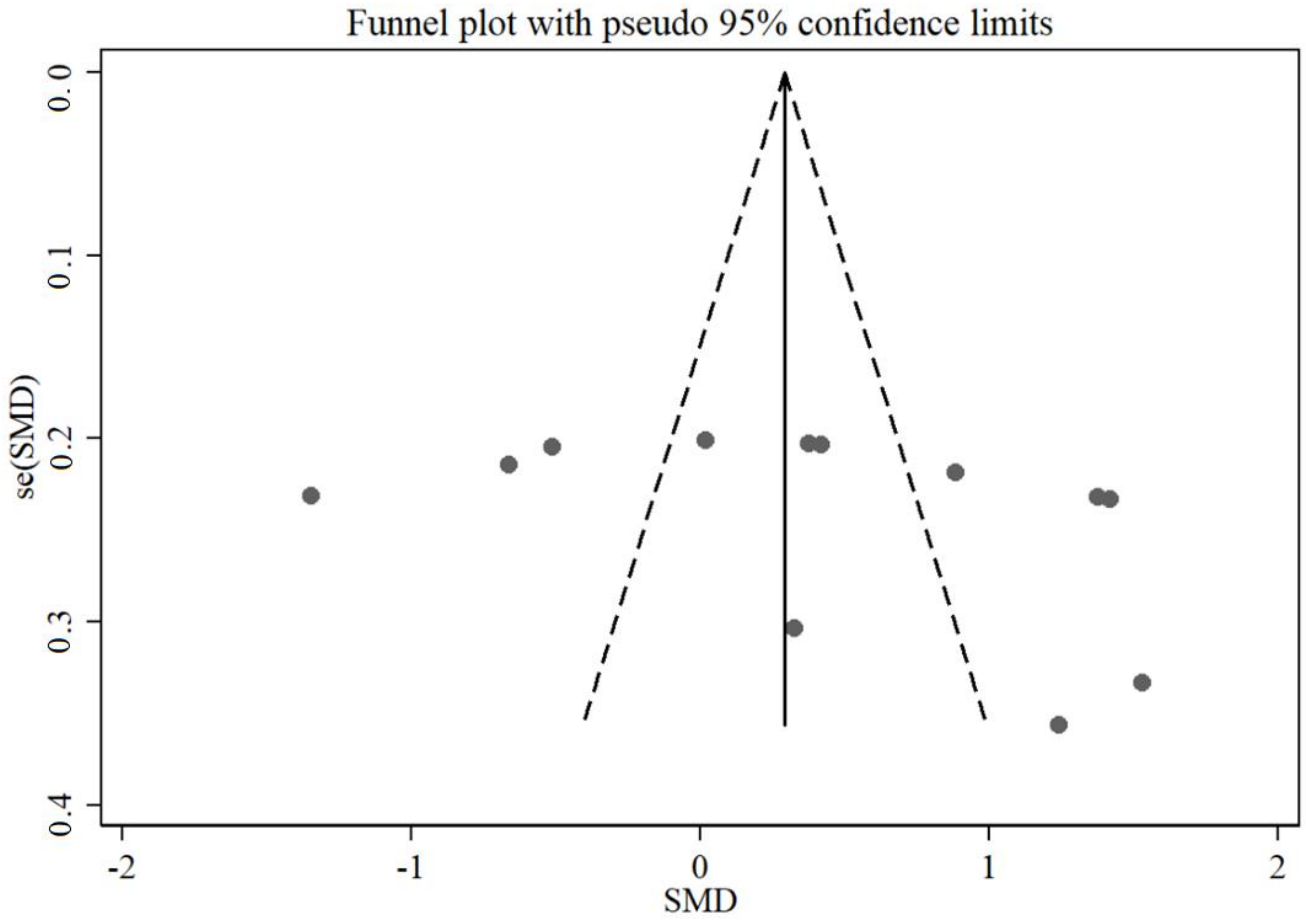

Figure 4. A funnel plot of publication bias of learning motivation.

Table 3. Test results of publication bias.

N	Outcome	n	Egger's Test		Begg's Test				Continuity Corrected	
			Bias	*p*	Score	sd	*z*	*p*	*z*	*p*
1	Critical thinking	5	14.17	0.111	6	4.08	1.47	0.142	1.22	0.221
2	Explicit reasoning	6	1.90	0.424	7	5.32	1.32	0.188	1.13	0.260
3	Learning achievement	33	4.36	0.083	34	64.54	0.53	0.598	0.51	0.609
4	Knowledge retention	5	10.18	0.061	6	4.08	1.47	0.142	1.22	0.221
5	Learning engagement	7	−0.14	0.946	9	6.66	1.35	0.176	1.20	0.230
6	Learning motivation	12	8.17	0.216	18	14.58	1.23	0.217	1.17	0.244
7	Learning interest	4	15.30	0.056	6	2.94	2.04	0.042	1.70	0.089

4.2. Results of Sensitivity Analysis

The researchers implemented a sensitivity analysis to examine the stability of meta-analytical results. As shown in Figure 5, all estimates range from the lower confidence interval limit (95% CI = 0.55) to the upper confidence interval limit (95% CI = 0.68). It indicates that none of the included studies could influence the pooled effect size when a specific study is omitted, confirming that the meta-analytical results are robust.

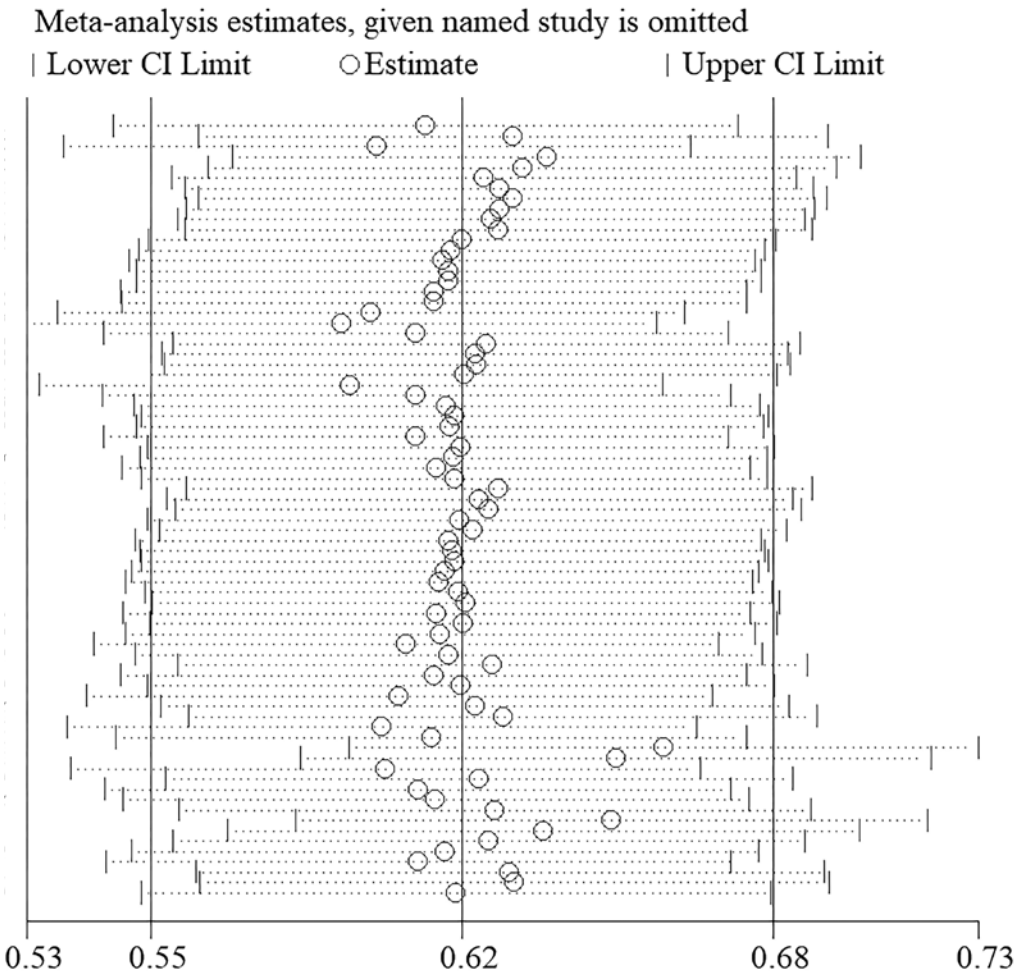

Figure 5. A plot of sensitivity analysis.

4.3. Results of Moderator Analyses

Table 4 presents the overall effect sizes of each outcome domain. Since I^2 statistics revealed that the effect size in critical thinking (Q = 55.89, I^2 = 92.8%, $p < 0.001$) was of considerable heterogeneity, the researchers adopted the random effects model. The effect

size did not show a significant difference in critical thinking (d = 0.690, 95% CI [−0.235, 1.615], p = 0.144) between the chatbot-assisted and conventional learning methods. Thus, the authors accepted hypothesis 1.

Table 4. The effect sizes of seven educational outcomes.

N	Outcome	Effect Size				Heterogeneity Test			
		d	95% CI	z	p	Q-Value	df	p	I^2
1	Critical thinking	0.690	−0.235, 1.615	1.46	0.144	55.89	4	0.000	92.8%
2	Explicit reasoning	1.190	0.868, 1.512	7.25	0.000	1.88	5	0.865	0.0%
3	Learning achievement	1.033	0.743, 1.322	6.99	0.000	221.14	32	0.000	85.5%
4	Knowledge retention	0.691	0.101, 1.281	2.29	0.022	22.96	4	0.000	82.6%
5	Learning engagement	0.147	−0.068, 0.363	1.34	0.180	3.22	6	0.780	0.0%
6	Learning motivation	0.409	−0.099, 0.916	1.58	0.114	161.61	11	0.000	93.2%
7	Learning interest	0.842	0.034, 1.650	2.04	0.041	23.39	3	0.000	87.2%
8	Overall	0.789	0.593, 0.985	7.90	0.000	582.09	71	0.000	87.8%

However, the effect size in explicit reasoning (Q = 1.88, I^2 = 0.0%, p = 0.865) was not significantly heterogeneous. The fixed effects model was thus used. Table 4 shows a significant difference in explicit reasoning (d = 1.190, 95% CI [0.868, 1.512], $p < 0.001$) between the experimental and control groups. The authors thus rejected hypothesis 2.

Effect sizes in both learning achievement (Q = 221.14, I^2 = 85.5%, $p < 0.001$) and knowledge retention (Q = 22.96, I^2 = 82.6%, $p < 0.001$) were considered heterogeneous. The authors accordingly employed the random effects model to pool the data. It was revealed that learning achievement (d = 1.033, 95% CI [0.743, 1.322], $p < 0.001$) and retention (d = 0.691, 95% CI [0.101, 1.281], p = 0.022) in the experimental group significantly improved compared with the control group. Therefore, the authors rejected hypotheses 3 and 4.

Because of I^2 = 0.0% in learning engagement (Q = 3.22), the effect sizes were of insignificant heterogeneity at the 0.05 level (p = 0.780). The authors thus chose the fixed effects model to pool the effect sizes. No significant differences in learning engagement (d = 0.147, 95% CI [−0.068, 0.363], p = 0.114) were found between chatbot-assisted and traditional learning methods. The authors, therefore, accepted hypothesis 5.

The effect sizes in learning motivation (Q = 161.61, I^2 = 93.2%, $p < 0.001$) and interest (Q = 23.39, I^2 = 87.2%, $p < 0.001$) were heterogeneous. Thus, the authors adopted the random effects model when conducting the meta-analysis regarding both educational outcomes. Meta-analytical results (Table 4) showed that compared with the control group, the experimental group maintained significantly higher levels of learning interest (d = 0.842, 95% CI [0.034, 1.650], p = 0.041). However, learning motivation in both groups was not significantly different (d = 0.409, 95% CI [−0.099, 0.916], p = 0.114). The authors thus accepted hypothesis 6 and rejected hypothesis 7.

The overall effect size of using chatbots in education was 0.789 ($p < 0.001$), with a 95% confidence interval between 0.593 and 0.985 (Table 4). According to Cohen's [69] effect-size criteria, which identified 0.2, 0.5, and 0.8 as small, medium, and large effect sizes respectively. The overall effect size in this study was thus considered as a medium-to-large level, indicating that the use of chatbot technology exerted a positive effect on learning outcomes. Additionally, the heterogeneity test showed that the overall effect size (Q = 582.09, I^2 = 87.8%, $p < 0.001$) was of considerable heterogeneity, which deserved further analysis to explore potentially critical moderator variables.

The researchers implemented a meta-regression analysis for three moderator variables (Table 5). Regarding intervention duration, there were medium-sized effects on chatbot-assisted learning for less than one week (d = 0.775, $p < 0.001$), less than 10 weeks (d = 0. 561, $p < 0.001$), and more than 10 weeks (d = 0.601, $p < 0.01$) and large-sized effects for less than 5 weeks (d = 1.060, $p < 0.05$) and not specified (d = 1.844, $p < 0.001$). However, there were no significant differences between effect sizes of the different intervention durations ($p > 0.05$). Thus, hypothesis 8 was accepted.

Table 5. The effect sizes of moderator variables.

N	Moderator Variable	Effect Size					Heterogeneity Test			
		n	*d*	95% CI	z	*p*	Coefficient	95% CI	t	*p*
1	Intervention duration						0.026	−0.194, 0.247	0.24	0.814
	Less than 1 week	39	0.775	0.561, 0.990	7.09	0.000				
	Less than 5 weeks	11	1.060	0.218, 1.902	2.47	0.014				
	Less than 10 weeks	18	0.561	0.318, 0.805	4.52	0.000				
	More than 10 weeks	2	0.601	0.203, 0.998	2.96	0.003				
	Not specified	2	1.844	1.496, 2.193	10.37	0.000				
2	Chatbot roles						−0.012	−0.271, 0.248	−0.09	0.930
	Teaching assistant	4	1.631	1.012, 2.250	5.17	0.000				
	Tutor	46	0.748	0.491, 1.005	5.71	0.000				
	Partner	22	0.712	0.438, 0.986	5.09	0.000				
3	Learning content						0.061	−0.147, 0.270	0.59	0.559
	Computer science	24	0.695	0.267, 1.123	3.18	0.001				
	Instructional technology	8	0.928	0.642, 1.215	6.35	0.000				
	Language	33	0.749	0.546, 0.951	7.25	0.000				
	Medicine	4	1.588	0.363, 2.812	2.54	0.011				
	Others	3	0.519	−0.422, 1.461	1.08	0.279				

The results for the remaining two variables presented similar patterns. Regarding chatbot roles, a large effect size was reported for using chatbots as teaching assistants ($d = 1.631$, $p < 0.001$), while the role of tutors ($d = 0.748$, $p < 0.001$) and partners ($d = 0.712$, $p < 0.001$) yielded medium effect sizes. Nevertheless, no significant differences existed between effect sizes of three roles of chatbots ($p > 0.05$). The authors thus accepted hypothesis 9.

In terms of learning content, computer science ($d = 0.695$, $p < 0.01$) and language ($d = 0.749$, $p < 0.01$) showed medium effect sizes, and large effect size estimates came from instructional technology ($d = 0.928$, $p < 0.001$) and medicine ($d = 1.588$, $p < 0.05$). The categories of math and military science were merged into one category (i.e., others) due to the limited studies, with no significant effect sizes ($d = 0.519$, $p > 0.05$). The meta-regression results revealed no statistically significant differences between the abovementioned values. Therefore, the authors accepted hypothesis 10. The results of the hypothesis testing are summarized in Table 6.

Table 6. The results of hypothesis testing.

N	Null Hypotheses	Results
1	The use of chatbot technology could not significantly improve critical thinking at the 0.05 level.	Accepted
2	The use of chatbot technology could not significantly improve explicit reasoning at the 0.05 level.	Rejected
3	The use of chatbot technology could not significantly improve learning achievement at the 0.05 level.	Rejected
4	The use of chatbot technology could not significantly improve knowledge retention at the 0.05 level.	Rejected
5	The use of chatbot technology could not significantly enhance learning engagement at the 0.05 level.	Accepted
6	The use of chatbot technology could not significantly enhance learning motivation at the 0.05 level.	Accepted
7	The use of chatbot technology could not significantly enhance learning interest at the 0.05 level.	Rejected
8	Intervention duration could not influence the effect of chatbot-assisted learning.	Accepted
9	Chatbot roles could not influence the effect of chatbot-assisted learning.	Accepted
10	Learning content could not influence the effect of chatbot-assisted learning.	Accepted

5. Discussion

This study investigated the effect of chatbot-assisted learning on various components and how different moderator variables influenced the effectiveness. There were no significant changes in critical thinking through the use of chatbots, which was inconsistent with the findings of Li et al. [13]. Although limited studies focused on critical thinking, there were still contradictory findings, probably because of the elusive property and different measurement instruments. Critical thinking is difficult to measure. Some studies

(e.g., [53]) used a newly developed scale consisting of five items. However, other studies (e.g., [61]) adopted the four-factor inventory developed through exploratory factor analysis. Chatbots may only exert influence on some dimensions of critical thinking, such as inquiring mindset.

The use of chatbot technology significantly enhanced explicit reasoning, which was also underexplored. The existing studies mainly developed students' explicit reasoning in collaborative activities since one display of explicit reasoning could associate with another one, which was the core of transactivity theory [70]. Chatbot interventions could effectively stimulate group discussions and help students utter their thoughts [55]. Chatbots also asked for clear and convincing statements, motivating students to find strong evidence. Thus, the conversational behaviors in the chatbot group were considered more transactive, i.e., with more explicit arguments, than those in the control group.

Chatbot technology also significantly improved learning achievement and retention. This finding was corroborated by the previous studies that confirmed the positive influence of chatbots on linguistic competence [10] and programming course achievement [33]. Chatbots can easily notice learners' knowledge gaps and accordingly make responses in order to create meaningful interactions. Review activities before presenting new information activate students' prior knowledge, facilitating the integration of the new and old knowledge [57]. Regarding knowledge retention, chatbots could randomly generate multiple-choice questions for declarative knowledge testing and open questions for procedural knowledge testing. Students in this way could timely recall their newly acquired information.

However, significant differences in learning engagement and motivation were not found between the chatbot-based condition and the control condition. One possible reason was that some students preferred to finish learning tasks in their own ways and paid little attention to chatbots [38], leading to a decrease in learning engagement. Another reason may be that factors such as peer feedback could influence motivation and that influencing factors varied with learning environments. Specifically, pressure was a significant predictor of motivation in the chatbot-assisted learning context, whereas perceived competency was an influencing factor in the traditional context [18].

With chatbot technology, students experienced more learning interest than those without it, supporting previous studies [10,43,46]. The enhancement of learning interest can be attributed to the flexibility of learning and affective feedback. Chatbot systems allowed users to learn based on individual needs and pace, which avoided frustration and learned helplessness for slow learners. Chatbots were designed to give encouraging messages if students failed to correctly answer questions [30]. They also gave human-like utterances such as *uh-huh* and *yeah*.

Three types of chatbot roles revealed no significant differences in learning outcomes. This finding echoed Huang et al.'s [1] suggestion for future research on determining how chatbots can be utilized to best achieve learning outcomes. Students can benefit from chatbot technology regardless of its roles. Chatbots were qualified as teaching assistants and learning partners since human teachers still took the leading role. Interestingly, chatbots could also be employed as tireless personal tutors. The intelligent systems guided and monitored students' personalized learning, while teachers had the opportunity and time to discover learners' potential problems [53], thus jointly promoting learning outcomes.

Intervention duration failed to influence the effectiveness of chatbot-based learning. The result did not indicate the novelty effect that learning outcomes may improve in the short term but ultimately decrease over time, which was inconsistent with the study [8]. It was possibly because a growing number of studies (e.g., [44,55]) have attempted to mitigate the novelty effect by introducing and familiarizing students with chatbot technology prior to intervention. Students in the information age can readily reach different technological innovations. Therefore, they were most likely to familiarize themselves with chatbots within several minutes.

Learning content was also not a significant variable. Moderator analysis suggested a more positive result for computer science, instructional technology, language, and medicine than the "others" category. Computer science and language were the most targeted fields in chatbot-based education, while engineering and mathematics received less attention [12]. Due to the small number of studies on other domains, educational fields such as military science and mathematics were subsumed into one category in this study. Therefore, it cannot be concluded that chatbots were more effective for certain learning content than for other categories.

6. Conclusions

6.1. Major Contributions

Methodologically, this study included major databases and conducted a meta-analysis under the PRISMA guidelines to examine the effectiveness of chatbot technology on educational outcomes. Theoretically, the results showed a medium-to-high overall effect size of chatbots on educational outcomes regardless of intervention duration, chatbot roles, and learning content. Chatbot technology exerted a significant and positive influence on explicit reasoning, learning achievement, knowledge retention, and learning interest. However, chatbots did not significantly improve critical thinking, learning engagement, and motivation. Practically, teachers and instructors could adopt appropriate teaching approaches to facilitate sustainable education.

6.2. Limitations

It should be noted that there are some limitations to the present study. First, the researchers only included studies written in English. Some publications, especially in Korean, could not be understood by the researchers. Second, this study only included three moderator variables that did not significantly influence the effectiveness of chatbots. Third, the results may still be influenced by unpublished studies with insignificant results despite the absence of publication bias.

6.3. Implications for Future Research

The findings may shed light on future research directions and propose suggestions for practitioners. First, the results revealed that chatbot-based learning was more effective than traditional learning in terms of explicit reasoning, learning achievement, knowledge retention, and learning interest. Therefore, future research could explore more components of educational outcomes, e.g., learning confidence, self-efficacy, social media use, and cognitive load. Experimental studies with large sample sizes are also expected. Teachers and instructors could integrate chatbot technology with different activities to meet learners' needs. Educational institutions could also provide training to improve teachers' and students' digital literacy and knowledge about artificial intelligence [71].

Second, future research could further explore users' attitudes towards chatbot technology and students' learning attitudes. Since the control group in the included studies did not obtain access to chatbots, it was difficult to compare users' attitudes between the control and intervention groups. Researchers could employ such models as the technology acceptance model and task-technology fit model to analyze the influencing factors of users' attitudes. On the other hand, learning attitudes could be compared. Only a few studies, however, focused on this aspect [43,57]. Future research could also expand chatbot research by using interdisciplinary research methods.

Third, intervention duration, chatbot roles, and learning content did not influence learning effectiveness. Thus, researchers could include more potential moderator variables for future meta-analyses, e.g., educational levels and interaction types. Future studies could also consider chatbot integration in other underexplored disciplines, e.g., arts, mathematics, and psychology [12]. Teachers could feel free to adopt chatbot-integrated teaching. They could introduce chatbot technology at any stage of the semester and assign any role to chatbots according to teaching needs. Developers and designers could introduce intriguing

elements by learning natural language processing and improve chatbots' performance based on machine learning algorithms.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15042940/s1, File S1: Supporting data; File S2: PRISMA checklist.

Author Contributions: Conceptualization, X.D. and Z.Y.; methodology, X.D.; software, X.D. and Z.Y.; validation, X.D. and Z.Y.; formal analysis, X.D. and Z.Y.; investigation, X.D.; resources, X.D.; data curation, X.D.; writing—original draft preparation, X.D.; writing—review and editing, Z.Y.; visualization, X.D.; supervision, Z.Y.; project administration, Z.Y.; funding acquisition, X.D. and Z.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the 2019 MOOC of Beijing Language and Culture University (MOOC201902) (important) "Introduction to Linguistics"; "Introduction to Linguistics" of online and offline mixed courses in Beijing Language and Culture University in 2020; the Special fund of Beijing Co-construction Project Research and reform of the "Undergraduate Teaching Reform and Innovation Project" of Beijing higher education in 2020-innovative "multilingual +" excellent talent training system (202010032003); The research project of Graduate Students of Beijing Language and Culture University "Xi Jinping: The Governance of China" (SJTS202108); The Fundamental Research Funds for the Central Universities, and the Research Funds of Beijing Language and Culture University (22YCX017).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available in File S1 in Supplementary Materials.

Acknowledgments: The authors would like to extend their gratitude to the people who help this study and the projects which financially support this study.

Conflicts of Interest: The authors declare no conflict of interest.

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A Study on Teachers' Continuance Intention to Use Technology in English Instruction in Western China Junior Secondary Schools

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Abstract: This study aimed to investigate the factors that affect the continuance intention to use technology among English teachers in China, mainly by examining the direct effects of help seeking, interest, effort regulation, growth mindset, facilitating conditions, perceived usefulness, and perceived ease of use on continuance intention (CI), and the indirect effects the above factors have on continuance intention through self-efficacy. The study sample comprised 459 English language teachers from junior secondary schools in different regions in Western China. A questionnaire that involved the above variables was used, and it was validated using exploratory factor analysis and confirmatory factor analysis. The results revealed significant direct effects of help seeking, effort regulation, growth mindset, facilitating conditions, perceived usefulness, and perceived ease of use on the continuance intention to use technology. However, the results showed that interest did not have a direct effect on the continuance intention to use technology. The findings also demonstrated that growth mindset, interest, effort regulation, help seeking, and perceived usefulness did not indirectly affect the continuance intention to use technology through self-efficacy. Nevertheless, the findings indicated that facilitating conditions and perceived ease of use did have an indirect effect on the continuance intention to use technology through self-efficacy. In light of these findings, some suggestions and recommendations were presented.

Keywords: continuance intention; instruction; self-efficacy; teachers; technology

Citation: Xie, Y.; Boudouaia, A.; Xu, J.; AL-Qadri, A.H.; Khattala, A.; Li, Y.; Aung, Y.M. A Study on Teachers' Continuance Intention to Use Technology in English Instruction in Western China Junior Secondary Schools. *Sustainability* **2023**, *15*, 4307. https://doi.org/10.3390/su15054307

Academic Editors: Rustam Shadiev, Barry Lee Reynolds and Rui Li

Received: 15 January 2023
Revised: 25 February 2023
Accepted: 27 February 2023
Published: 28 February 2023

1. Introduction

English instruction has mushroomed worldwide over the past decades due to its significance for national development. As a consequence of the options that it provides for teachers and students, the teaching of this language as a foreign language has advanced simultaneously with the ever-accelerated advancement of technology. In view of this, it has been noticed that the incorporation of technology into English instruction in China has substantially increased. Every English as a foreign language (EFL) reform attempt must include the use of technology [1,2].

Technology has been seen as an e-learning tool for democratizing classroom communication, and this has afforded some English teachers with new possibilities to encourage Chinese students to utilize English [3,4]. Now, teachers have a greater variety of implementation method options (e.g., online and blended, in addition to face-to-face) [5,6]. In this sense, the continued use of technology is crucial for sustaining academic success in an EFL environment. The continuance intention is essential because it provides consistency and

sustainability for the advancement of teaching and learning. Despite its significance, there are few studies examining the continuance intention (CI) of technology use among EFL instructors [7,8]. An increasing amount of research and attention is being paid to the role that technology may play in EFL classrooms [9–11]. The use of technology in the classroom has been shown to be notably useful for the instruction and improvement of fundamental language abilities, including listening, speaking, reading, writing, grammar, vocabulary, and pronunciation [8,9,12–14]. However, teachers of languages (as opposed to subjects like physics and math) are often slower and less effective in technology integration due to their own educational backgrounds [15–17]. In this regard, it seems necessary to explore continuance intention in the EFL context.

Furthermore, there is a shortage of studies that investigate the continuance intention to use technology in instruction, and a need for future research [18]. For example, some previous studies focused more on the acceptance and adoption of multimedia online learning [19]. Other studies have investigated the continuation of technology use in terms of technostress and attitudes [20], perceived pedagogical impact and user interface quality [21], satisfaction in the blended learning context [22], intrinsic and extrinsic work motivation and occupational stress (i.e., burnout and technostress, which have been examined in tandem) [23], and perceived convenience and curiosity [24]. Previous research results suggest that other variables may affect the continuance intention to use technology [25,26]. These factors include learning behaviors, perceptions, motivational beliefs, and facilitating conditions [27–30]. More particularly, some studies have explored growth mindset (GM) with technology use [31,32], interest (IN) with ICT [33], facilitating conditions (FC) and help seeking (HS) with mobile learning and e-learning [25,26], and perceived usefulness (PU) and perceived ease of use (PEU) with general intentions to use technology [34,35]. However, to the best of our knowledge, there is a shortage of investigations into the impact of these factors on the continuance intention to use technology in an EFL context [7]. Moreover, with the advent of technology in education, English teachers form their own beliefs about their abilities in using technology, which may have a role in determining their intention. There is a strong correlation between teachers' levels of self-efficacy (SE) and the quality of the learning environments they foster, suggesting that instructors' confidence in their own abilities to implement new strategies may have a significant influence on student achievement [36,37]. In studies of teachers' propensity to accept new forms of technology, self-efficacy has been shown to be an essential variable to examine [38–40]. Self-efficacy may reduce the impact of several factors on continuance intention since instructors who have high levels of it are more likely to stick with their goals despite setbacks and to find creative solutions to problems that arise [41,42]; hence, their self-efficacy can mediate the effects of different factors on their continuance intention. Therefore, this study introduces growth mindset, interest, facilitating conditions, effort regulation, help seeking, perceived usefulness, and perceived ease of use as factors that can affect teachers' continuance intention to use technology in instruction in the Chinese context and from the teacher's perspective. In addition, this study introduces SE as a mediator variable that can mediate the effects of the above factors on continuance intention.

Despite the researchers' review of previous studies on teachers' intentions to keep using technology in the classroom, there was a lack of high-quality empirical studies on teachers' intentions to keep using technology in the classroom, which included the perspective of English language teachers and the mediating effects of self-efficacy. Our study set out to fill that void. This research aimed to better understand the variables that influence English instructors' continuance intention for adopting new technologies in the classroom. Specifically, this research aimed to examine the effects of help seeking, interest, effort regulation, growth mindset, facilitating conditions, perceived usefulness, and perceived ease of use on continuance intention, and the role of self-efficacy in mediating the relationship between these factors and continuance intention. With the objective of enhancing the quality of EFL instruction and learning, this study may aid policymakers in making better informed choices on the deployment of different resources to support teachers' professional

development in the area of classroom technology usage. It is conceivable that this study may offer cutting-edge research on the pressing issue of the continuance intention to use technology, which is of great concern to schools and governments worldwide. These latest results not only verified the findings of earlier studies, but also improved our knowledge of how EFL instructors interact with and use technology. This has far-reaching implications for the globalization of English in the context of foreign language instruction.

1.1. Theoretical Background

The technology acceptance model (TAM) was first put forward by Davis and his colleagues [43]. The TAM has always been the most frequently applied model for depicting technology acceptance in the domain of education [44]. The model proposes that the intention to utilize technology tools is influenced by two perceptions, i.e., the perceived usefulness and the perceived ease of use of the tools [45]. Later, the scope of the TAM was expanded by Rauniar (2014) [46], with other factors being included, such as facilitating conditions that highlight environmental characteristics. The above-mentioned perceptions and the factor of facilitating conditions have been studied and shown to be useful in predicting people's acceptance and utilization of modern information technology.

In recent years, an increasing number of researchers have investigated how motivational beliefs shed light on perceptions and technology acceptance [47]. The power of motivational beliefs is that they highlight teachers' general beliefs about technology use on the basis of previous experience [48]. These motivational beliefs can have a profound effect on people's perceptions about the utilization of technology tools and applications.

The expectancy–value theory, one of the most powerful motivational theories, argues that people's expectancies about the possibilities of success (e.g., self-efficacy) and subjective task values (e.g., utility values, playfulness, and cost) tend to determine their initiation and perseverance [49]. The more an individual is convinced that s/he can perform a task well, the more enjoyment s/he will obtain in performing the given task, and the less pessimistic s/he will be in the process of performing that activity. All these factors will be conducive to a higher level of acceptance of that task. In terms of technology application, positive personal traits such as self-efficacy will contribute to positive intentions.

In addition, in the process of defining continuance intention, a learning perspective is considered to complement the TAM. The rationale for the impact of learning behaviors on continuance intention is that teachers' personal strong intentions to learn about how to apply technology in their instruction will contribute to more technology being used in their teaching [5]. Since most teachers, as digital immigrants, were born and raised before the digital age and were thus exposed to technology at a relatively older age compared to digital natives, they have more difficulties in combining technology with teaching [50]. At present, a wide range of teacher education programs are offered to better teachers' competence in applying technology in teaching, particularly for teachers in universities or in-service teachers in the workplace. While participating in technology development programs, these teachers will be more likely to engage in learning, and their learning behaviors should be beneficial for their subsequent continued technology use, on the condition that they hold a firm belief that they can better their technology competence through learning (i.e., a growth mindset). Based on the literature about students' academic engagement [51], it is expected that teachers who have a growth mindset will be positively involved in learning about how to apply technology and this will enhance their competence with more continuance intention towards technology use.

1.2. Literature Review

With the advancement of computer technology in the new millennium, it has become a common and indispensable tool that allows students to control their own learning to achieve a longer-term learning goal, including gaining foreign language learning experiences [52]. The purpose of the TAM is to explain the main factors of user behavior towards technology user acceptance [53]. Teachers' continuance intention is determined by different

variables. Perceived ease of use and perceived usefulness are two main components of the TAM. Perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort. Perceived usefulness refers to the degree to which a person believes that using a particular system will increase his or her job performance. Perceived ease of use and perceived usefulness affect the attitude towards using technology, which is conceptualized as an attitude towards the use of a system in the form of acceptance or rejection [53]. As a teacher becomes more accountable and interested in the use of technology in the classroom, perceptions develop, confidence takes root, interest is augmented, and concern about its use becomes commonplace. Thus, one's perceptions become an integral part of both efficacy and one's interest in having the ability to continue using technology. Furthermore, effort regulation and help seeking are two more factors. Effort regulation is the ability to monitor and sustain effort even when the content is difficult, frustrating, or boring. However, help seeking is understood as the current intention to seek help from different sources for different problems, as well as the quantity and quality of previous professional psychological helping episodes [54]. Teachers must be able to learn during and from practice since teaching knowledge is rarely fully acquired prior to or separate from practice [55]. Effort regulation and help seeking are essential here as they lead to effectiveness in instruction [56,57]. In this regard, effort regulation and help seeking can improve teachers' self-efficacy and interest, and hence, reduce their anxiety in teaching. Good teachers who succeed in using technology in instruction regulate their teaching practices and seek help from colleagues to prevent any negative emotional factors. This may help them avoid problems in using technology in their classrooms.

Moreover, the factor of facilitating conditions is considered to be a construct used in research to measure the level of perception of the user regarding the support of the organizational environment and the needed infrastructure to use the new technology. Facilitating conditions are organizational and technical infrastructure supporting the use of acquired systems in their contexts. A teacher might utilize technology resources to change some instructional behaviors in response to changing environmental conditions [5]. Hence, this factor can reduce the anxiety level of the teacher and simultaneously boost them to move back and forth between positive motives and technology implementation.

According to Dweck's theory of mindsets (2000, 2006) [58,59], individuals may hold either a growth mindset or a fixed mindset, which pertains to their beliefs about the malleability of traits such as intellect and ability. A growth mindset is characterized by the belief that these traits can be developed through effort and learning, while a fixed mindset is characterized by the belief that they are fixed and incapable of change. Research conducted by Blackwell et al. (2007) [60] suggests that individuals with a growth mindset tend to exhibit stronger learning goals and more positive beliefs about the role of effort in achieving success, and they are more inclined to engage in effort-based strategies. In education, growth-minded teachers use process-based pedagogy to foster a positive learning atmosphere, whereas fixed-minded teachers emphasize students' fundamental traits, which might lower motivation and tenacity [61]. The link between teachers' mindsets and their use of technology in the classroom has been substantiated through research, with Alshehri (2022) [31] and Teo et al. (2018) [62] both finding a significant relationship between teachers' mindsets and their use of technology in the classroom, with those having a growth mindset being more likely to utilize technology in their teaching. White (2019) [32] asserts that a "digital mindset," or confidence in one's ability to develop digital skills and adapt professional practices accordingly, is essential for individuals in the teaching profession to keep pace with the rapid development and adoption of new technologies. Teachers' mindsets can impact their use of technology and teaching practices, making it an important area of investigation. Ergen (2019) [63] also found that teachers with a growth mindset tend to have higher self-efficacy in using technology as they believe in their ability to acquire and apply new skills, while those with a fixed mindset may have lower self-efficacy and less willingness to integrate technology in their teaching.

Another important factor is self-efficacy. This is the capacity to believe in one's own ability to accomplish tasks [64]. Teacher self-efficacy, specifically, refers to a teacher's belief in their ability to effectively carry out their teaching responsibilities within a particular setting [65]. High self-efficacy increases a teacher's likelihood of being prepared, enthusiastic, and resilient in the face of challenges. The use of technology in the classroom can impact teacher self-efficacy, with those who possess self-efficacy in technology use being more motivated to use it in teaching [66]. However, teachers often have low levels of competence and self-efficacy with technology [67,68]. Factors that may impact teacher self-efficacy with technology include age and gender [69], computer experience [70], and school support [71]. In terms of basic and advanced computer skills, for instance, Scherer and Siddiq (2015) [69] found that male teachers tended to have higher levels of self-efficacy. These findings highlight the complexity of the relationship between self-efficacy and technology use in the classroom. For example, high self-efficacy and interest in technology can lead to a greater intention to continue using technology in the future, while low self-efficacy can result in a decreased likelihood of technology use [63]. These interrelated factors illustrate the importance of considering self-efficacy in discussions about teacher technology use.

Professional development that sparks teachers' interest and motivates them to engage in exploration and learning can enhance their ability to adapt to new demands and challenges in their profession and improve their students' learning outcomes [72]. Interest is a mental and emotional state marked by rapt attention, pleasure, and excitement that develop in response to exposure to intriguing objects or ideas [73]. It is accompanied by the maturing of a person's affective and cognitive dimensions and may stimulate an intrinsic desire to engage in a certain activity or topic [74]. Hidi (2006) [74] suggests that teachers may have the greatest influence on their students' achievement if they assist them to develop academically relevant interests. An adequate level of interest in using technology is crucial for teachers to effectively integrate it into their teaching practices [33]. However, maintaining this level of interest requires ongoing professional development and support from school leaders. Online teaching, for example, has become a popular choice among EFL teachers and students due to its ability to foster learner autonomy and identity formation through hybrid uses of language [75]. Despite English teachers in China having positive attitudes towards technology use, their actual use of technology in teaching is limited and peripheral [76]. Therefore, promoting professional development that sparks teachers' interest and motivates them to engage in exploration and learning to improve their students' learning outcomes is of high importance.

Technology has gained attention in education for its potential to improve teaching and learning outcomes [77]. Continuance intention, or the intention to continue using a technology after initial acceptance, has been studied in relation to ICT adoption and usage [78,79]. Motivational beliefs such as self-efficacy and interest, learning behaviors, and facilitating conditions can influence continuance intention [43,80]. Technology self-efficacy, a supportive atmosphere, interest, and a growth mindset all had favorable impacts on the intentions of teachers of English as a second language to keep using technology in their classrooms [43,80]. For instance, a school culture that values and encourages the use of technology in education can motivate ESL teachers to persist in incorporating technology into their teaching methods. In contrast, anxiety had a negative impact on teachers' technology continuance intention. The objectives that should drive professional development programs for teachers include fostering a growth mindset and encouraging instructors to seek help when needed.

1.3. Research Aims and Hypotheses

Based on the review of previous studies, this research aimed to examine the effects of help seeking, interest, effort regulation, growth mindset, facilitating conditions, perceived usefulness, and perceived ease of use on continuance intention, and the mediating role of self-efficacy in the relationship between the above-mentioned factors and continuance inten-

tion. The following hypotheses were tested during the course of this investigation. Figure 1 illustrates the relationship between the variables and hypotheses of the present study:

- There are direct effects of effort regulation (H_1), facilitating conditions (H_2), interest (H_3), growth mindset (H_4), help seeking (H_5), perceived ease of use (H_6), and perceived usefulness (H_7) on teachers' continuance intention to use technology in EFL instruction;
- There are indirect effects of effort regulation (H_8), facilitating conditions (H_9), interest (H_{10}), growth mindset (H_{11}), help seeking (H_{12}), perceived ease of use (H_{13}), and perceived usefulness (H_{14}) on teachers' continuance intention to use technology in EFL instruction through self-efficacy.

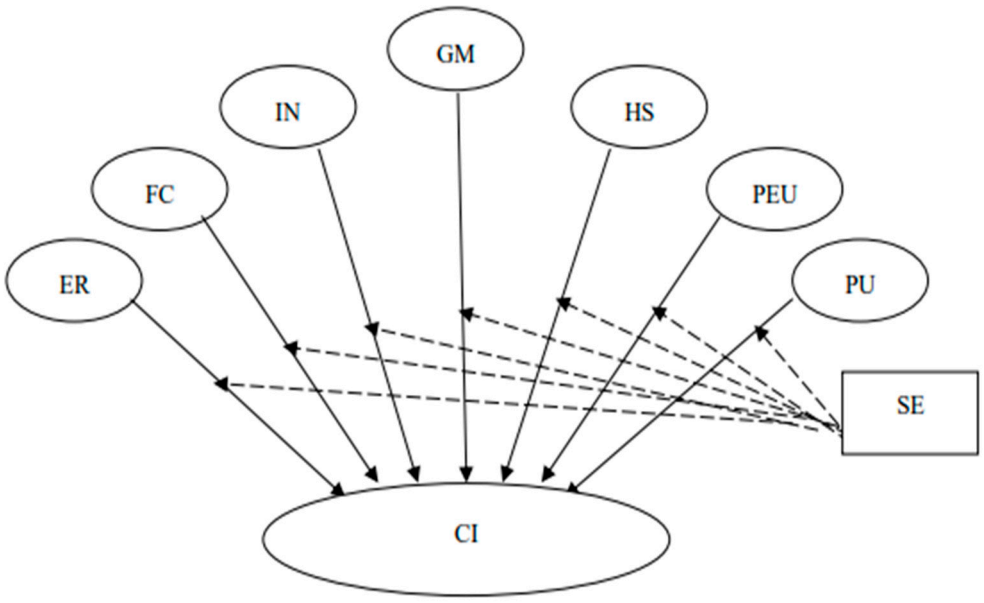

Figure 1. The hypothesized study model.

2. Methodology

2.1. Research Design

This study focused on teachers' continuance intention to use technology. The TAM was used. This study is quantitative. A cross-sectional research design was adopted as it helps in the collection of data from a wide range of participants and, hence, to explore and measure the interactions that exist between variables. The authors are a group of international researchers from China and other two countries, Algeria and Myanmar. Their identities range widely from professors, postdoctoral fellows, to Ph.D. students. They are composed of both female and male researchers. None of them had any effect on the choice of the scope and aims of the study, nor did they have any effect on the research methods adopted to accomplish the study. To provide a relevant and trustworthy example of technology-based teaching, which may influence the education systems of other nations, they all felt the need to investigate students' continuance intention to use technology in a highly developed country, namely China, that strongly supports the implementation of technology in education. To obtain opinions from a large number of Chinese participants, they opted for a quantitative strategy based mostly on a cross-sectional research design.

2.2. Procedures

The researchers were aware that, for any study, the validity and reliability of the questionnaire is a significant issue to assure the correctness and validity of the results. To attain this, following ethical guidelines in data collection is critical and indispensable. In this regard, a written agreement was obtained from the Research Ethics Committee of the School of Foreign Languages, Huazhong University of Science and Technology

(HUST), to collect data for study aims. English teachers were selected using a purposive sampling procedure from different junior secondary schools in Western China. Purposive sampling entails picking units based on certain criteria that are necessary and appropriate for the study [5,6]. The selection process was based on the location of the participants. The researchers sought to achieve balance in the numbers of teachers from rural and urban schools. The reason for this is the fact that teaching in rural and urban areas in the western parts of China is not the same. There are some differences in terms of the supply and use of technology, teaching quality, academic achievements, the support provided to schools and teachers, contextual conditions inside the schools, and the level of the students. The researchers started by contacting the junior secondary school principals. The first researcher explained the study to the principals and asked them to contact their teachers. Meetings with teachers were arranged with the help of the principals. However, most of the teachers were contacted online due to the effects of the COVID-19 pandemic. The first researcher explained the study to the teachers and confirmed to them that the data would be kept private and used only for the study aims. All of them agreed to participate. Then, a consent letter was obtained from each of the participants.

A total of 601 teachers from junior secondary schools in rural and urban areas of Western China participated in the current study. Among these 601 teachers, there were some who had been contacted at their schools by some friends of the researchers, whereas others were contacted online using WeChat and QQ applications. The participants who were contacted online could not be reached face-to-face due to the COVID-19 pandemic situation in their cities. In this regard, only fully answered questionnaire forms were taken into account. In the end, a total of 459 English teachers from 15 junior secondary schools in Western China were counted since they provided complete answers to the questionnaire.

2.3. Participants

The final sample of participants comprised 459 English language teachers from different regions in Western China, including Guangxi, Guizhou, Gansu, Qinghai, Xinjiang, Yunnan, Ningxia, Shaanxi, and Enshi Autonomous Prefecture in Hubei, during the 2021–2022 academic year. Sixteen junior secondary schools participated in this study. Most of these schools were based in rural and urban areas in Western China and they all used technology in instruction and learning. There were eight located in urban areas, whereas eight were located in rural areas in Western China. As shown in Table 1, of the 459 teachers, 216 were male and 243 were female; 206 teachers had a bachelor's degree, 163 teachers had a master's degree, whereas 90 teachers had other degrees. The ages of the teachers were categorized in five categories: 69 teachers were 30 years old or younger, 133 teachers were between 31 and 35 years old, 82 teachers were between 36 and 40 years old, 105 teachers were between 41 and 45 years old, and 70 teachers were 46 or above.

Table 1. Participants' profiles.

Demographic Variables	Frequency	Percentage	M	SD
Gender	459	100		
Male	216	47.1	1.529	0.499
Female	243	52.9		
Education Level	459	100		
Bachelor	206	44.9	1.747	0.763
Master	163	35.5		
Others	90	19.6		
Age	459	100		
30 years old and less	69	15	2.943	1.315
31–35	133	29		
36–40	82	17.9		
41–45	105	22.9		
46 years old and above	70	15.3		

2.4. Research Instrument

The questionnaire of Bai et al. (2021) [7] was used in the current study. The tool was initially derived from Pintrich et al. (1991) [81], Morris et al. (2003) [82], Dweck (2006) [59], Chiu and Wang (2008) [83], and Liaw and Huang (2013) [80], and was modified to fit the context of English teaching. As shown in Table 2, the scale entails thirty-seven items distributed among nine factors: facilitating conditions (four items), self-efficacy (four items), interest (four items), perceived ease of use (four items), perceived usefulness (four items), growth mindset (four items), effort regulation (five items), help seeking (four items), and continuance intention (four items).

Table 2. Questionnaire factors and items.

Scale Factors	Number of Items
Facilitating conditions	4
Self-efficacy	4
Interest	4
Perceived ease of use	4
Perceived usefulness	4
Growth mindset	4
Effort regulation	5
Help seeking	4
Continuance intention	4

This scale had been used by Bai et al. (2021) [7] in a Chinese context, in Hong Kong, but to guarantee its suitability for the Western China context, it was provided to some experts for evaluation. The five experts suggested keeping the scale as it had been formulated by Bai et al. (2021) [7] since the items are clear and can fit also the Western China educational context. However, they suggested conducting pilot testing of the scale, to confirm its validity and reliability. The pilot testing was then performed with 106 teachers to support the validity evaluation of the experts. The Cronbach's alpha (α) was found to be adequate, with a value of 0.81; hence, the validity was determined to be 0.91.

3. Data Analysis

The analysis went through exploratory factor analysis and confirmatory factor analysis. Data entry was carried out using Statistical Product and Service Solutions (SPSS) Software (Version 22.0) and SmartPLS. As the data entry was one of the essential processes in this study, it was carried out with particular attention to obtain valid results. Finally, data analysis and interpretation were conducted.

4. Research Instrument Validity and Reliability

This study aimed to examine the effects of growth mindset, interest, facilitating conditions, effort regulation, help seeking, perceived ease of use, and perceived usefulness on teachers' continuance intention to use technology in teaching, and the mediation effect of self-efficacy on these relationships. The factorial validity was examined to confirm the validity of the scale. The KMO obtained in this study (KMO = 0.951) was greater than the values suggested by previous studies [84]. BST was found to be significant (x^2 = 11,914.1892; $p \leq 0.001$). Hence, normal distribution of data with multiple variables was affirmed. These results demonstrated that the questionnaire was appropriate for factor analysis [85,86]. The most likely number of variables to match the data was nine. As indicated in Table 3 and Figure 2, the number of factors that best suited the data was most likely nine. The initial EFA for 37 items with eigenvalues revealed a nine-factor structure, which was greater than 1 that could be extracted, accounting for 73.106% of the total variance [84,86].

Table 3. Eigenvalues and percentage of variance explaining the factors.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
ER	15.100	40.810	40.810	15.100	40.810	40.810	7.029	18.996	18.996
FC	2.781	7.516	48.327	2.781	7.516	48.327	4.054	10.956	29.952
IN	2.078	5.616	53.942	2.078	5.616	53.942	3.326	8.988	38.941
GM	2.009	5.430	59.373	2.009	5.430	59.373	2.796	7.558	46.498
GS	1.219	3.295	62.668	1.219	3.295	62.668	2.437	6.588	53.086
HS	1.118	3.022	65.690	1.118	3.022	65.690	2.432	6.573	59.659
PEU	1.070	2.731	68.421	1.070	2.731	68.421	2.409	6.511	66.170
PU	1.014	2.417	70.837	1.014	2.417	70.837	1.540	4.162	70.332
ER	1.001	2.268	73.106	1.001	2.268	73.106	1.026	2.774	73.106

Extraction Method: Principal Component Analysis.

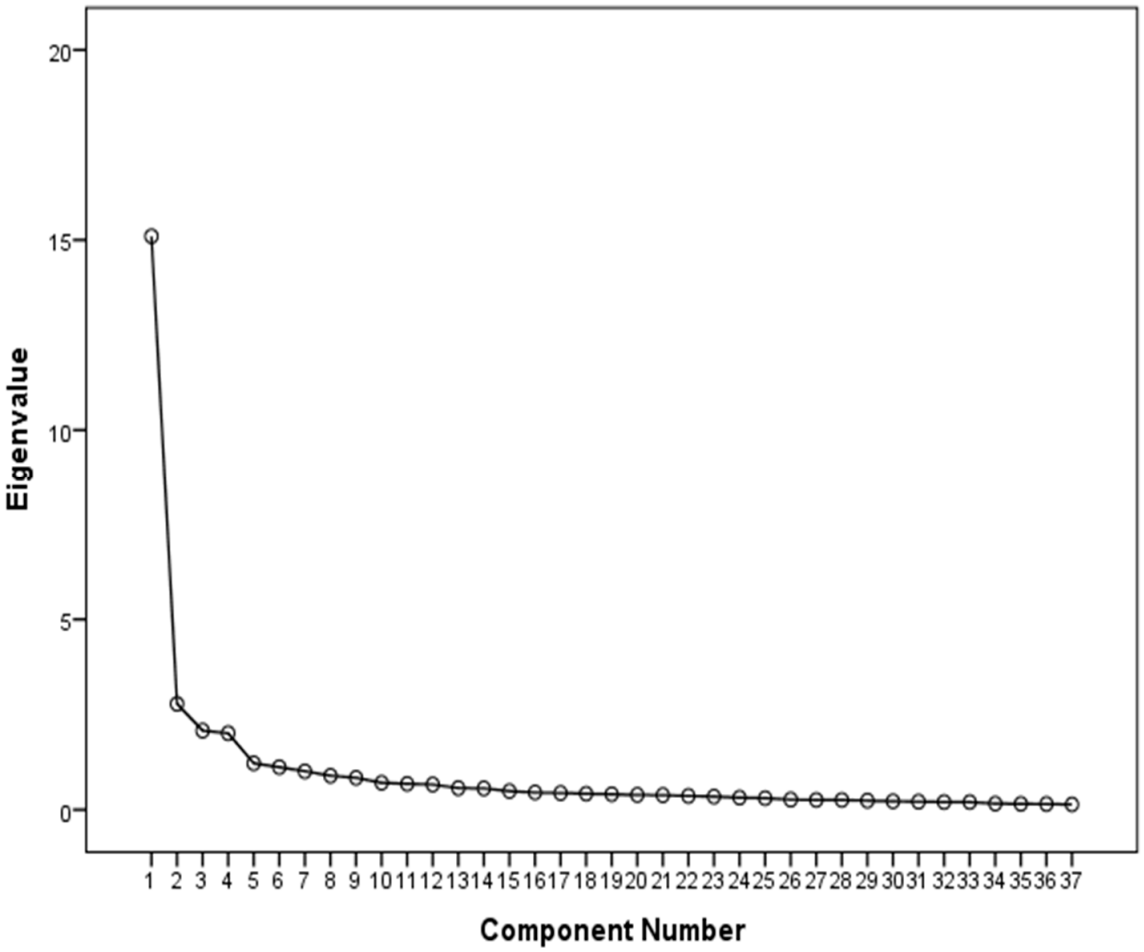

Figure 2. Scree plot of the study questionnaire.

The initial EFA with eigenvalues for 37 items revealed a nine-factor structure. The results showed that the same 37 items that were distributed among nine factors as their factor loads were all higher than 0.40: facilitating conditions (four items) with a factor load range between 0.730 and 0.488, self-efficacy (four items) with a factor load range between 0.849 and 0.578, interest (four items) with a factor load range between 0.814 and 0.727, perceived ease of use (four items) with a factor load range between 0.901 and 0.884, perceived usefulness (four items) with a factor load range between 0.808 and 0.780, growth mindset (four items) with a factor load range between 0.674 and 0.606, effort regulation (five items) with a factor load range between 0.723 and 0.643, help seeking (four items) with a factor load range between 0.643 and 0.430, and continuance intention (four items) with a factor load range between 0.771 and 0.425. Confirmatory factor analysis was also executed

to confirm the research instrument items and all loading values were higher than 0.48, and all factor loadings were statistically significant at $p < 0.01$.

In addition, the measurement model was assessed using multiple fit indices, including $x^2/DF = 2.498$, the root mean square error of approximation (RMSEA) = 0.067, the comparative fit index (CFI) = 0.921, the goodness of fit index (GFI) = 0.966., and the Tucker–Lewis index (TLI) = 0.903. All these values of the fit indices seemed to be appropriate [84] and they confirmed the validity of the proposed model, and that the final nine-factor model fit well.

The Cronbach's alpha (α) values for each component were 0.783, 0.711, 0.862, 0.793, 0.792, 0.834, 0.773, 0.709 and 0.807, respectively. All of these values were suitable and acceptable for this measurement [87]. The composite reliability (CR) values for each factor were 0.765, 0.834, 0.785, and 0.841. All the average variance extracted (AVE) values were higher than 0.50, indicating a good approximation of validity [86,88]. In order to evaluate discriminant validity, each factor that contained the AVE was also tested with the squared correlation. The proof of discriminant validity was satisfactory [84,89].

5. Results

SmartPLS was employed to test the model's explanatory capacity based on adopting resampling methods to simplify calculating the PLS coefficient's significance [90]. The fit indices were assessed and proved the appropriateness and validity of the model since the following values were found to be suitable and high [84]: SRMR = 0.057, d_ULS = 2.282, d_G = 0.814, Chi-Square (x^2) = 2181.486, NFI = 0.903, and rms Theta = 0.122. Table 4 presents the construct reliability and validity, whereas Table 5 presents discriminant validity. All values were adequate and confirmed the model quality [91].

Table 4. Construct reliability and validity of the study model.

Variables	α	rho_A	CR	AVE
CI	0.809	0.891	0.879	0.661
ER	0.832	0.854	0.881	0.599
FC	0.809	0.811	0.877	0.724
IN	0.900	0.901	0.938	0.833
GM	0.820	0.822	0.893	0.735
GS	0.898	0.900	0.929	0.766
HS	0.750	0.811	0.780	0.527
PEU	0.898	0.899	0.929	0.767
PU	0.862	0.869	0.907	0.709

Note: α = Cronbach's alpha, CR = composite reliability, AVE = average variance extracted.

Table 5. Discriminant validity of the study model.

	CI	ER	FC	GI	GM	GS	HS	PEU	PU
CI	0.831								
ER	0.731	0.774							
FC	0.462	0.385	0.851						
IN	0.643	0.642	0.396	0.931					
GM	0.706	0.742	0.367	0.694	0.857				
GS	0.553	0.511	0.454	0.558	0.556	0.875			
HS	0.684	0.662	0.371	0.523	0.597	0.450	0.726		
PEU	0.480	0.577	0.245	0.609	0.634	0.554	0.448	0.876	
PU	0.710	0.756	0.391	0.744	0.759	0.523	0.581	0.614	0.842

Then, the hypotheses were assessed as presented in Table 6 below. Concerning the assessment of the direct effect, the bootstrap resampling method with 5000 resamples [92] was carried out. The direct effects of all hypotheses were accepted, except the effect of interest on continuance intention (β = 0.068, Std = 0.053, t = 1.270, *p*-value = 0.205). Table 6 shows the significant positive effects of effort regulation on continuance intention (β = 0.217, Std = 0.060, t = 3.637, *p*-value = 0.000), of facilitating conditions on continuance intention (β = 0.086, Std = 0.031, t = 2.754, *p*-value = 0.006), of growth mindset on continuance intention (β = 0.179, Std = 0.053, t= 3.346, *p*-value = 0.001), of help seeking on continuance intention (β = 0.259, Std = 0.049, t = 5.251, *p*-value = 0.000), of perceived ease of use on continuance intention (β = 0.104, Std = 0.040, t = 2.577, *p*-value = 0.010), and of perceived usefulness on continuance intention (β = 0.160, Std = 0.060, t = 2.645, *p*-value = 0.008).

Table 6. Direct effects among the study variables.

Hypotheses	Direct Effect	β	M	SD	*t*-Test Value	*p*-Value	Decision
H_1	ER→CI	0.217	0.229	0.060	3.637	0.000	Supported
H_2	FC→CI	0.086	0.086	0.031	2.754	0.006	Supported
H_3	IN→CI	0.068	0.062	0.053	1.270	0.205	Unsupported
H_4	GM→CI	0.179	0.171	0.053	3.346	0.001	Supported
H_5	HS→CI	0.259	0.262	0.049	5.251	0.000	Supported
H_6	PEU→CI	0.104	0.106	0.040	2.577	0.010	Supported
H_7	PU→CI	0.160	0.160	0.060	2.645	0.008	Supported

To test the mediation of self-efficacy, Preacher and Hayes's (2008) [93] method was used, and *p*-values of indirect effects were obtained through bootstrapping with 5000 resamples [92]. The results confirmed significant indirect effects on continuance intention through the mediation of self-efficacy for only two variables, facilitating conditions (β = 0.027, Std = 0.012, t = 2.194, *p*-value = 0.029) and perceived ease of use (β = 0.030, Std = 0.014, t = 2.192, *p*-value = 0.029); hence, the two related hypotheses were supported. However, the analyses revealed that self-efficacy had no mediation effect on the effects of effort regulation on continuance intention (β = 0.003, Std = 0.009, t = 0.329, *p*-value = 0.742), of interest on continuance intention (β = 0.018, Std = 0.011, t = 1.651, p-value = 0.099), of growth mindset on continuance intention (β = 0.015, Std = 0.011, t = 1.352, *p*-value = 0.177), of help seeking on continuance intention (β = 0.007, Std = 0.007, t = 1.068, *p*-value = 0.286), or of perceived usefulness on continuance intention (β = 0.003, Std = 0.009, t = 0.397, *p*-value = 0.691); therefore, the related hypotheses were unsupported. The results are illustrated in Table 7 and Figure 3.

Table 7. Indirect effects among the study variables.

Hypotheses	Direct Effect	β	M	SD	*t*-Test Values	*p*-Values	Decision
H_8	ER→SE→CI	0.003	0.003	0.009	0.329	0.742	Unsupported
H_9	FC→SE→CI	0.027	0.028	0.012	2.194	0.029	Supported
H_{10}	IN→SE→CI	0.018	0.019	0.011	1.651	0.099	Unsupported
H_{11}	GM→SE→CI	0.015	0.015	0.011	1.352	0.177	Unsupported
H_{12}	HS→SE→CI	0.007	0.008	0.007	1.068	0.286	Unsupported
H_{13}	PEU→SE→CI	0.030	0.031	0.014	2.192	0.029	Supported
H_{14}	PU→SE→CI	−0.003	−0.003	0.009	0.397	0.691	Unsupported

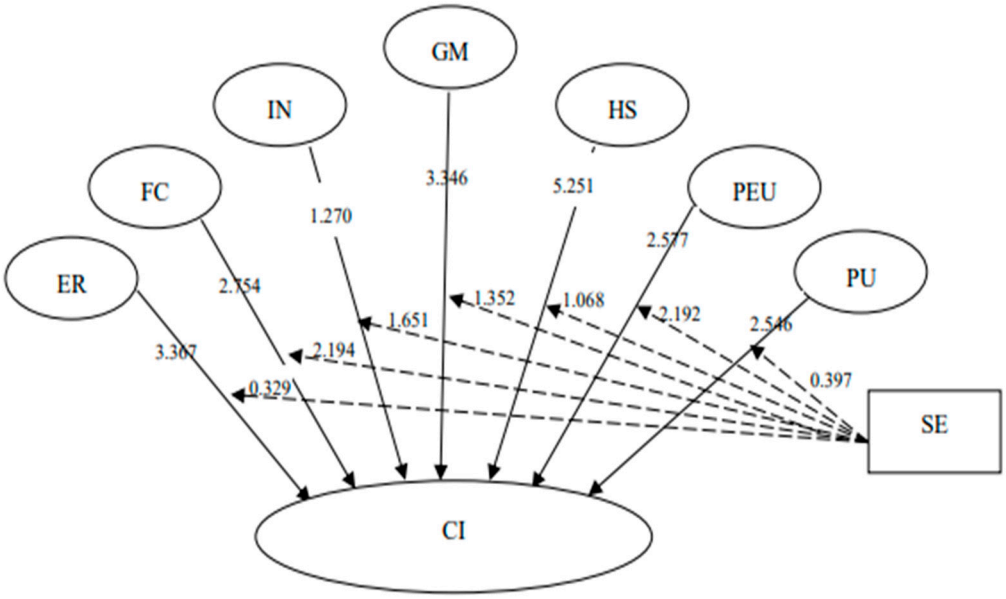

Figure 3. Structural model.

6. Discussion

The current study aimed to investigate the continuance intention to use technology in teaching among Chinese teachers of English in junior secondary schools in Western China. After following various procedures to obtain a large number of participants, as presented above, the final sample included 459 teachers from Guangxi, Guizhou, Gansu, Qinghai, Xinjiang, Yunnan, Ningxia, Shaanxi, and Enshi Autonomous Prefecture in Hubei. After checking the surface validity, pilot testing, final distribution of the questionnaire, and lastly, measuring the questionnaire's validity and reliability, the questionnaire validity and reliability were confirmed to entail thirty-seven items.

The hypotheses of the present study were of two types, including direct and indirect effects. The direct effect hypotheses included the effects of the growth mindset, facilitating conditions, interest, effort regulation, help seeking, perceived ease of use, and perceived usefulness on the continuance intention to use technology in teaching. The results revealed that a direct effect existed between growth mindset, facilitating conditions, effort regulation, help seeking, perceived ease of use, and perceived usefulness and the continuance intention to use technology in teaching, since the P values were less than 0.05. These results were similar to the study of Tang et al. (2021) [26], which showed that the growth mindset, help seeking, and perceived usefulness significantly determined teachers' intention to adopt mobile technology as an enhanced teaching platform. Meanwhile, Tang et al. (2021) [26] found that the perceived ease of use factor had no effect. On the other hand, it has been shown that the perceived ease of use and perceived usefulness of mobile technology have a direct influence on teachers' intentions to use technology in their classrooms [34,35]. When tutors have greater expertise or comfort with the technology, they will find it simpler to employ mobile devices to aid them in online instruction [26,34]. This, in turn, will influence their beliefs and actions about the continuing adoption of the technology [94]. The result related to the effect of effort regulation on continuance intention contradicted the study of Bai et al. (2021) [7], which found that effort regulation did not have a positive direct effect on continuance intention among Chinese primary teachers. However, the study of Bai et al. (2021) [7] was conducted in Hong Kong and the authors explained that the primary school teachers there did not need much effort to acquire knowledge about how to use technology tools, while the participants in the current study were teachers in junior secondary schools in Western China and they needed to become familiar with using technology, especially the technology that has developed and spread recently in China and the new inventions being introduced in education. Some studies that have

been conducted on the topic of people's inclination to accept and use different educational technologies, such as e-learning and mobile learning, have placed an emphasis on the role that facilitating conditions play in this phenomenon [7,25]. These studies highlight how crucial it is to create settings that are pleasant for users in order to encourage broad adoption of technologies [95]. However, our analysis revealed that no effect exists between interest and continuance intention. This result contradicted the study of Bai et al. (2021) [7], which found significant direct and positive effects of interest on continuance intention. This finding also differed from the study of Lai and Chen (2011) [96], which found that teachers' satisfaction in using technology was directly and positively connected with their adoption of blogs. The possible reason for this is that, as the use of technology has become a regular and normal issue in teaching, the intention to continue using technology has become normal but it still demands effort, positive perceptions, cooperation between teachers, and a conducive environment.

Concerning the indirect effects that were explored between variables in which self-efficacy was a mediator variable, varying results were obtained. Surprisingly, indirect effects of growth mindset, interest, effort regulation, help seeking, and perceived usefulness on continuance intention through self-efficacy were not confirmed. The explanation could be that self-efficacy may have been at a low level among the participants [67,68], which made its contribution as a mediator without having an effect, while effort, positive perceptions, cooperation between teachers, and their interests had a considerable influence on continuance intention, as confirmed above. Therefore, it is necessary to make appropriate plans to promote self-efficacy among Chinese teachers of English language in junior secondary schools. Meanwhile, the results confirmed the indirect effects of facilitating conditions and perceived ease of use on continuance intention through self-efficacy. These results were similar to the study of An et al. (2022) [97], which found that technological self-efficacy mediated the relationship between continuance intention to use technology and self-directed learning. This result also supported the study of Sharma and Saini (2022) [37], which revealed that self-efficacy plays a moderating role in the relationship between continuance intention and the actual use of technology. It is reasonable to assume that when the surrounding environment is favorable for instructors and they view a technology to be very user-friendly, their positive beliefs about incorporating technology in teaching will grow, hence increasing their utilization of technology.

7. Conclusions

There has never been a more crucial moment for English instructors to become adept with and manage technology-based teaching. Therefore, it is essential to understand the factors driving the continuance intention of instructors to use technology in the classroom. This research aimed to uncover the factors that affect English language teachers' continuance intention to use technology in the junior secondary schools of Western China. It investigated the relationships between growth mindset, facilitating conditions, effort regulation, help seeking, interest, perceived ease of use, and perceived usefulness and continuance intention, as well as the role of self-efficacy as a mediator. Teachers' intention to continue using technology was shown to be influenced by the growth mindset, facilitating conditions, effort regulation, help seeking, perceived ease of use, and perceived usefulness. However, the research demonstrated that interest had no role or effect. Facilitating conditions and perceived ease of use did have an indirect effect on continuance intention through self-efficacy. However, self-efficacy did not mediate the effects of the growth mindset, interest, effort regulation, help seeking, and perceived usefulness on continuance intention. As a result, it is recommended that instructors attempt to increase their self-efficacy in order to increase students' motivation to persevere with technology. These findings suggest that policies and practices for EFL-instruction-based technology over the next few years can take a variety of forms. The government should prioritize the planned improvement of technology-based instruction training programs in order to increase teachers' interest, motivation, and perspectives, thereby ensuring their intention to

continue utilizing technology. In addition, the government should increase the supply of necessary technology devices for teachers while indirectly enhancing teachers' intention to use technology. Similarly, teachers should participate in training programs offered by the government and other agencies and collaborate with government, colleagues, school principals, and researchers to improve the efficacy of the technology used in instruction, which may lead to an increase in the proportion of tutors who intend to continue using technology.

8. Limitations and Future Research Directions

There were several limitations to this research. Age, gender, and other socio-demographic factors were disregarded. For the sake of precision, future studies might benefit from the incorporation of demographic data when estimating how likely participants are to maintain their current levels of continuance intention to use technology. This study focused on the effects of the growth mindset, facilitating conditions, interest, effort regulation, help seeking, perceived ease of use, and perceived usefulness on continuance intention to use technology in teaching. These factors may not provide an accurate or complete depiction of what influences continuance intention. Future research could examine a broad variety of past studies, or conduct qualitative investigations, to explore additional factors. This research also focused on continuance intention, which may not provide a complete picture of the actual use of technology in education. Future studies could address actual technology use. A total of 459 junior high school instructors of English in Western China responded to the survey, but this did not capture the demographics of professors or the variety of students at other institutions. Consequently, care must be used when extrapolating these results to the whole teaching force. The recruitment of educators in a wide variety of institutions is strongly recommended for future studies for the reason that junior high school English instructors were the primary focus of this research. Other areas of China (the east, the south, and the north), educational levels (including higher education institutions), and fields of study (hard sciences, social sciences, and the humanities) might be the focus of future studies. The employment of a single research approach throughout the survey also did not add to the study's credibility. There are different opinions as to whether or not it could fully and accurately represent the opinions of the people who participated. Future studies on this topic would be more convincing if they included data on interviews and classroom observations.

Author Contributions: Conceptualization, Y.X., A.B. and Y.L.; Methodology, A.H.A.-Q.; Software, Y.M.A.; Validation, J.X. and A.H.A.-Q.; Formal analysis, A.H.A.-Q. and Y.M.A.; Investigation, Y.X. and J.X.; Resources, A.B. and A.K.; Data curation, A.B. and J.X.; Writing—original draft, A.B. and A.K.; Writing—review & editing, Y.X., A.B. and J.X.; Supervision, A.B.; Project administration, A.B. and Y.L.; Funding acquisition, Y.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was conducted in accordance with all the required ethical considerations and practices. The study was approved by the Research Ethics Committee of the School of Foreign Languages, Huazhong University of Science and Technology (HUST).

Informed Consent Statement: Informed consent was gathered from all participating teachers. Confidentiality was maintained by not requesting names or any other information that would identify the teachers involved. The subjects were informed of their right to withdraw from the investigation at any time.

Data Availability Statement: Data will be made available on request.

Conflicts of Interest: No potential conflict of interest was reported by the authors.

Abbreviations

EFL: English as a foreign language, HS: help seeking, IN: interest, ER: effort regulation, GM: growth mindset, FC: facilitating conditions, PU: perceived usefulness, PEU: perceived ease of use, SE: self-efficacy, CI: continuance intention.

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Article

Applications of Reciprocal Teaching in Flipped Classroom to Facilitate High Level of Cognition for Sustainable Learning Practices

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Abstract: In traditional engineering education, students usually have little training on project implementation. Therefore, students have few chances to cultivate and develop their high-level cognitive abilities for the sake of achieving sustainable learning practices. We carried out two consecutive studies to overcome this issue. In both studies, we incorporated a flipped classroom approach into the project-based engineering education curriculum. Twelve junior graduate students majoring in electrical engineering participated in Study 1, and ten junior graduate students participated in Study 2. They all took the Signal Processing of Power Quality Disturbances class and practiced their skills in a computer lab, using LabView software. After we found from the results of Study 1 that the learning activities placed a heavier load on students and their advanced cognitive skills were not developed well, the reciprocal teaching method was introduced to students in Study 2. We assumed that the reciprocal teaching method could improve these outcomes, as well as achieve sustainable learning practices. The results demonstrated that students' load in Study 2 was reduced, and their high-level cognitive skills improved compared to those in Study 1. Based on these results, we conclude that the reciprocal teaching method can be incorporated into the flipped classroom during project-based engineering education, as it helps prevent students from becoming overloaded, facilitates cognitive abilities from basic to high, and ensures sustainable learning practices.

Keywords: engineering curriculum; project-based learning; flipped classroom; reciprocal teaching

Citation: Hwang, W.-Y.; Wu, T.-H.; Shadiev, R. Applications of Reciprocal Teaching in Flipped Classroom to Facilitate High Level of Cognition for Sustainable Learning Practices. *Sustainability* **2023**, *15*, 5848. https://doi.org/10.3390/su15075848

Academic Editor: Antonio P. Gutierrez de Blume

Received: 10 February 2023
Revised: 18 March 2023
Accepted: 20 March 2023
Published: 28 March 2023

1. Introduction

At present, engineering courses such as the Signal Processing of Power Quality Disturbances course are mostly theoretical and focus on the derivation of relevant theories and models. Most of them aim to equip students with necessary knowledge, which is the basic level of cognition. Therefore, high cognitive abilities, such as application of new knowledge to solve real-life problems or creativity, are overlooked by the instructors. That is, most engineering classes are organized in a way in which the instructor delivers lectures and students passively acquire knowledge. In such circumstances, students have very limited chances to develop their higher-level cognition.

Furthermore, for some students—especially those with active experimenter and reflective observer learning styles—classes that emphasize lecture over practice are not very useful. Thus, there is a mismatch between the learning styles of engineering students and teaching styles of engineering instructors. As a consequence of this mismatch, students become bored and inattentive in class, perform poorly, have low learning motivation, and, in some cases, they change or even drop out of such courses. Instructors, confronted by low learning outcomes, such as test scores, unresponsive or hostile classes, poor attendance, and dropouts, know that something is not working. They may become overly critical

toward their students, thus making things even worse. As a result, society loses potentially excellent engineers [1]. From the above, we can understand that students in the field of engineering education lack experience in cooperation and expressing their ideas, as well as necessary practical skills. Furthermore, the research on engineering education rarely explores learners' cognitive development in practice, especially with respect to high cognitive levels, i.e., the application of newly learned knowledge to new contexts or creativity.

Such problems need to be addressed by educators and researchers. In addition, sustainable teaching and learning practices should be achieved. That is, such practices take place when educators and researchers equip their students with the skills and strategies that help them engage in lifelong independent learning though various experiential project-based learning tasks that require research, critical thinking, and collaboration.

In this research, we aimed to promote students' skills and enhance their high-level cognitive abilities by incorporating the reciprocal teaching method in the flipped classroom into a project-based engineering curriculum and achieve sustainable teaching and learning practices. This study aimed to address the following research questions: What are learning experiences and outcomes of the students studying the signal processing of power quality disturbances under the project-based learning approach and flipped classroom strategy? How can implementation of the reciprocal teaching method facilitate the learning experiences and outcomes of the students?

2. Literature Review

2.1. Flipped Classroom

The flipped classroom has become a popular teaching strategy recently [2–6]. Fulton [7] claimed that the flipped classroom is advantageous for learning because (1) students move at their own pace; (2) doing "homework" in class gives teachers better insight into student difficulties and learning styles; (3) teachers can more easily customize and update the curriculum and provide it to students 24/7; (4) classroom time can be used more effectively and creatively; (5) teachers using the method report seeing increased levels of student achievement, interest, and engagement; (6) learning theory supports the new approaches; and (7) the use of technology is flexible and appropriate for "21st century learning." For these reasons, the flipped approach was successfully applied in engineering education [3–6]. For example, Mavromihales and Holmes [3] presented a method to deliver a workshop based on the flipped learning approach. The scholars explored whether the flipped classroom approach can enhance the learning experience through better engagement with the students as compared to conventional classroom-based learning. The level of student participation and level of success were established in the study. Merrett [4] combined flipped classroom instruction, case-based learning in an active classroom, and authentic assessments in an Introduction to Engineering Materials Course. Merrett [4] found that flipped classroom instruction had a negligible effect on students' final exam performance compared to a traditional lecture mode, and case-based learning had a positive impact on students' quiz and laboratory scores. Therefore, Merrett [4] suggested the use of a flipped classroom approach with case-based learning in an active classroom, and authentic assessments are recommended for teaching engineering materials. Saterbak et al. [5] implemented and assessed a flipped classroom approach for first-year engineering design. The scholars implemented a flipped classroom approach that emphasized the development of higher cognitive levels for the students. Student learning was assessed, and outcomes from the flipped approach and the lecture approach showed no statistically significant differences because it was an inquiry-based course since its inception. Zhang and his colleagues [6] integrated mobile learning and SPOC-based flipped classroom to teach an engineering course.

Their approach included pre-class (knowledge acquisition), in-class (knowledge internalization), and after-class (knowledge application) stages. Zhang and his colleagues adopted the WeChat applet Mu classroom with m-learning technology in the in-class stage. They also designed several interactive activities based on the Mu classroom to improve the

teacher–student interactions. The results showed that, after using such an approach, the average score of the final exam improved, and the failed percentage decreased. Furthermore, positive feedback from students was received, stating that the approach was effective and motivated students' learning interests and knowledge understanding.

Finally, several pitfalls of the flipped approach were also reported in the literature. For example, students new to the method may be initially resistant because it requires that they do work at home rather than be first exposed to the subject matter in school. Consequently, they may come unprepared to class to participate in the active learning phase of the course [8].

2.2. Project-Based Learning

Project-based learning (PBL) is a model that organizes learning around projects [9,10]. Thomas [11] defines PBL as an approach which includes authentic content, authentic assessment, and student-centered learning activities with clear and detailed teaching goals. During the PBL learning process, learners must learn to find the problem out and have the ability to implement, collect, and integrate information and to train the communication skills with others through the group discussions, and try to propose a solution to the problem with others [12,13]. In order to promote the interaction between the teacher and students and students' ability to actively think about a problem and solve it in PBL flipping classrooms, the other most important thing is to inspire students to develop their higher level of cognition.

Many scholars explored how PBL approach can lead to a higher level of cognition, particularly in engineering education. For example, Nurbekova et al. [14] used the PBL approach in engineering education to teach mobile application development. The scholars explored the impact of the used approach on the students' cognitive skills. The impact of the approach was evaluated through the questionnaire, and its effectiveness was confirmed by the empirical data. Sulisworo [15] attempted to improve higher-order thinking skills through the project-based learning approach on STEM education settings. The experimental group learned under the PBL approach, and the control group was exposed to scientific learning. The results demonstrated the positive impact of the PBL approach on the students' higher-order-thinking skills.

2.3. Reciprocal Teaching

Reciprocal teaching routines force students to respond, even if the level of which they are capable is not yet that of an expert. However, because the students do respond, the teacher has an opportunity to gauge their competence and provide appropriate feedback. In this way, the procedure provides an opportunity for the students continuously make progress until they approach full competence [16].

Reciprocal teaching is an instructional procedure designed to teach students cognitive strategies that might lead to their improved comprehension [17]. Learning about cognitive strategies such as summarization, question generation, clarification, and prediction can be supported through dialogue between the teacher and students as they attempt to gain meaning from the learning content. Reciprocal teaching has two major features. The first is the instruction and practice of four comprehension-fostering strategies: question generation, summarization, prediction, and clarification. The second is the usage of reciprocal teaching dialogue as a vehicle for learning and practicing these four strategies. In reciprocal teaching, however, much greater emphasis is placed on encouraging students to provide instructional support for each other [18].

Reciprocal teaching received considerable attention in the field. For example, Zewail-Foote and Gonzalez [17] designed a crisscrossing learning experience (CCLE) course to promote a high level of collaboration, sense of ownership, and science identity among first-year students through the learning via the teaching paradigm and close mentoring. Nnamani et al. [19] researched the effects of reciprocal peer tutoring strategies on computer students' achievement. According to the scholars, the reciprocal peer tutoring strategy

had a significant effect on computer students' achievement in expository essay writing. Nnamani et al. [19] argued that expository essay writing skills are very important for computer students and that reciprocal peer tutoring should be adopted as a teaching strategy for expository essays in technical institutions. Reciprocal teaching strategies were applied in Shadiev et al. [20] to computer-programming learning. The scholars investigated the effects of reciprocal teaching strategies on learning outcomes. The results showed that the students who used reciprocal teaching strategies outperformed students who did not use them in regard to the level of cognition of program concept and program writing. The reason is that the reciprocal teaching strategies facilitate students to write program codes, as well as to explain them to their peers.

Informed by related studies, we applied reciprocal teaching in the flipped classroom to facilitate a high level of cognition for sustainable learning practices. The learning activity was designed by following the project-based learning (PBL) methodology. With such an integrative approach, we aimed to cultivate and develop engineering students' high-level cognitive abilities. As can be seen from the literature review, not many studies had such an integrative approach or focused on the development of engineering students' high level of cognitive abilities.

3. Methods

The research method was a case study [21]. According to Creswell [22], a case study is an in-depth exploration of a bounded system (e.g., activity, event, or process) based on extensive data collection. That is, in a case study, researchers focus on a program, event, or activity involving individuals or a group. We particularly employed a multiple instrumental case study. We focused on illuminating a specific issue (how to facilitate a high level of cognition for sustainable learning practices), with cases (Study 1 and Study 2) used to illustrate the issue. We described and compared cases to provide insight into an issue [8].

3.1. Participants and Research Architecture

The research architecture is shown in Figure 1. Our research was divided into two studies, i.e., Study 1 and Study 2. In Study 1, twelve junior graduate students majoring in electrical engineering participated. All of them were males. They were divided into six pairs.

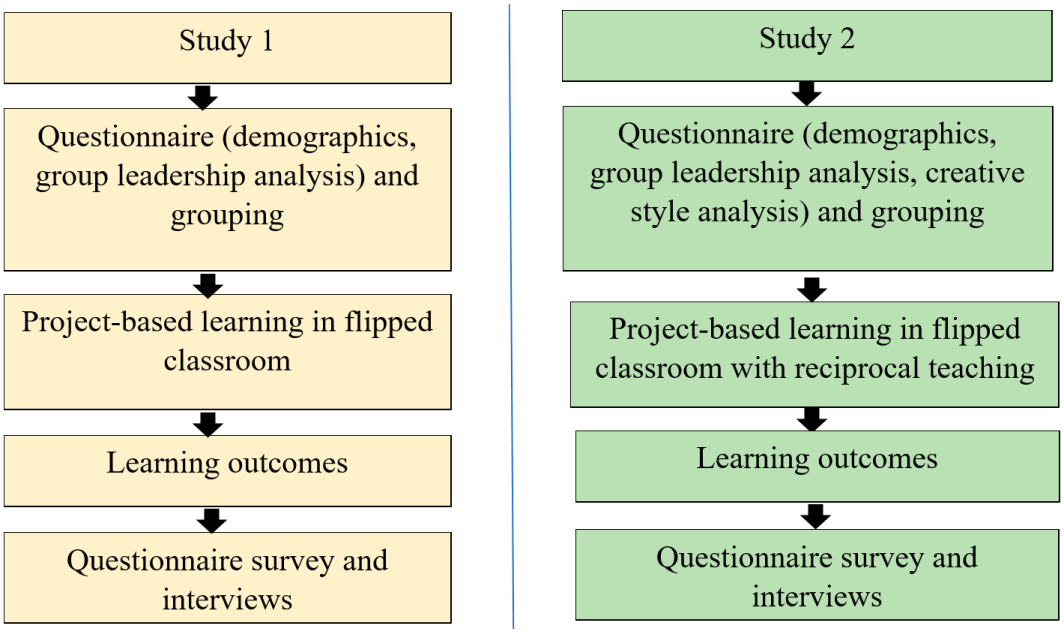

Figure 1. Research architecture.

The course administered in this study was Signal Processing of Power Quality Disturbances. The learning activity was designed following the project-based learning (PBL) approach in Study 1. Students worked on assigned real-world problems individually and collaboratively to obtain hands-on experience. A flipped classroom, an instructional strategy was used; that is, the students completed pre-class work, e.g., studying learning content and searching for certain information on the Internet to gain basic knowledge. Then, in class, they applied and mastered newly learned knowledge through problem-solving activities, discussions, giving/receiving feedback, reflections, and collaboration. The study was carried out in the computer laboratory and the participants used LabView (Laboratory Virtual Instrument Engineering Workbench) to design and simulate their ideas about power signal processing. LabView is a simulation software for testing, measuring, and controlling engineering design in the laboratories. It can help students to understand the specific knowledge of engineering applications through graphical programming and representation. Using displaying logic diagrams and algorithm analysis, the students can improve their practical experience and understanding of power signal processing. The students designed their ideas into products and then operated and debugged their products. The teacher and teaching assistant helped the students when necessary. For example, the students asked a teacher or teaching assistant questions when they encountered any difficulties. Therefore, after practical experience, the students could develop their high-level cognition and reach such cognitive levels as application or analysis (see Bloom's Taxonomy in Anderson et al. [23]). More details about LabVIEW software can be found from LabVIEW [24].

Every week, before the class, the students were assigned to develop a weekly preview of related learning content. The students had to summarize their ideas generated from their weekly preview, write them down, and then hand them in as a pre-class assignment report. Then, in class, each group was asked to do a presentation and share their ideas. Other groups had to give feedback or share their ideas related to the presentations. Finally, after class, each group was asked to revise its weekly preview report and hand in a revised version (called as a weekly report) by integrating peer feedback and ideas shared by others. Regarding monthly reports (or project reports), each group needed to hand in a project report monthly by integrating what the group members learned each month.

After investigating students' learning perceptions of their learning experiences through interviews, we found that the students required more time to practice their skills with hand-on tools, as this can enhance their understanding and application of knowledge learned in class to solve real-life problems. Moreover, we found that the students encountered difficulties in pre-class study and answering pre-class questions given by the teacher, as they often had a superficial understanding of learning content before class. Last but not least, students' higher level of cognition was not developed very well. Therefore, Study 2 was carried out after Study 1, with several modifications in the initial design of the learning activity.

In Study 2, ten junior graduate students with a major in electrical engineering participated. All of them were males. In order to motivate students to have more engagement and creativity in group discussion and collaboration (e.g., students with high leadership and creativity in each pair can lead discussions and brainstorm ideas to improve their pair learning), students were assigned to different pairs based on their creativity style and the personality related to leadership. To this end, the participants were surveyed using Big Five personality questionnaires and the creativity styles questionnaire [25]. Two dimensions of the Big Five personality, openness to experience and extraversion, were used to represent the potential of students' leadership. Finally, the normal S-type grouping based on scores of leadership and creativity was employed to divide students evenly into different groups. The students were divided into five pairs, and each pair had students with heterogeneous attributes in leadership and creativity. The learning activity followed the PBL approach, and the flipped classroom strategy was used. The same teacher instructed the participants in Study 1 and Study 2. Both studies were 18 weeks long, and the students learned about the electric circuit in the Signal Processing of Power Quality Disturbances course. The

only difference between the two studies was the reciprocal teaching approach that was introduced in Study 2. Reciprocal teaching, in this study, refers to student interaction with peers through explaining, questioning, and clarifying difficulties, new concepts, and applied methods that were used [20]. Reciprocal teaching included the following major dimensions (Figure 2). (1) Summary: Identify the main point about the content and make it become 2~3 sentences to capture what you read. (2) Ask questions: Listen to the problems in your mind, e.g., what will...? or how come...? and write it down. (3) Clarify: List all unfamiliar things, link with your prior knowledge, and then answer any questions. (4) Forecast: Expect those parts which will happen or connect next and write down your forecast.

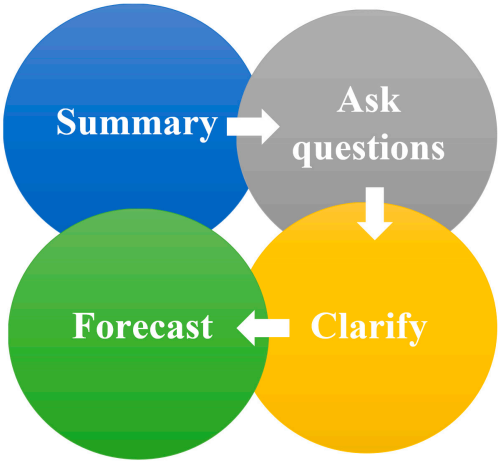

Figure 2. Reciprocal teaching activity.

Both collaborative learning (Study 1) and reciprocal teaching (Study 2) align with social constructivism theory [26]. According to this theory, learners are active participants in the creation of their own knowledge. It was suggested that a central notion in social constructivism is assisted learning, a concept that is influenced by socio-culturalism and its concept of proximal learning. Although both activities align with social constructivism theory, they are quite different in nature and, as we assumed, bring about different learning effects.

3.2. Research Instruments

The following research instruments were used: group leadership, creative style, project score, a post-test questionnaire, and interviews.

The group leadership questionnaire was developed based on the Big Five personality traits examination tool [27]. It measures the following learner characteristics: (a) openness to change, innovation, new experience, and learning; (b) conscientiousness, self-discipline, dutiful act, and aim for achievement; (c) extraversion—tendency to be sociable, talkative, and have positive emotions; (d) agreeableness—to be kind, sympathetic, cooperative, and considerate; and (e) neuroticism—experience unpleasant emotions (e.g., anger, anxiety, and depression) easily. The group-leadership data were collected in both studies.

The creative style questionnaire was adopted from the study by Kumar et al. [25]. There were 78 items in the questionnaire. Both the group leadership and creative style questionnaires were validated through scrutiny of the instructor and two experts. The creative style data were collected in Study 2 only.

Learning outcomes, such as scores for the weekly preview and report, as well as monthly report, were measured. Weekly previews and reports were measured right after they were submitted, and final project reports were evaluated at the end of the semester. We used the revised version of Bloom's Taxonomy [23] for the data analysis. Figure 3 shows different cognitive levels and the colors corresponding to them. Representing cognitive levels in corresponding colors was helpful in coding content created by the students.

Figure 3. Bloom's Taxonomy.

Bloom's Taxonomy was also used. It includes six levels. The remember level refers to recognizing or recalling knowledge from memory. Remembering is when memory is used to produce or retrieve definitions, facts, or lists, or to recite previously learned information. The understand level represents constructing meaning from different types of functions, be they written or graphic messages or activities. The apply level consists of carrying out or using a procedure by executing or implementing it. The analyze level involves breaking materials or concepts into parts, determining how the parts relate to one another or how they interrelate, or determining how the parts relate to an overall structure or purpose. The evaluate level represents making judgments based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation.

We adjusted the definitions of the taxonomy as follows. Remember: Basic judgments for various power quality events (e.g., harmonics, flicker, voltage swell, voltage dip, etc.). Understand: Learn about the various algorithms' analysis methods, principles, and applicable power quality events. Apply: Use LabView software to simulate power events and implement the algorithm. Analyze: Students can analyze the algorithms of power events and understand how they work. Evaluate: Students comment on the merits and demerits of experiments based on the algorithmic norms and standards they learned and experiences they had. Create: Improve the original algorithm or propose innovative ideas and incorporate them into the group project at the end of the term.

We encoded student weekly previews and reports and monthly project reports. We used the color encoding of content based on Bloom's taxonomy. The data and content presented by the students were classified into six levels of the taxonomy, with different colors. For example, the green color represents the remember level, and the yellow color represents the create level (see Figure 3 for colors and related levels of the taxonomy).

After the encoding process, the statistics on the number of the six cognitive levels were performed. Finally, we explored and observed the relationship between trend changes and research variables.

A post-test questionnaire with several items was carried out at the end of each study. The first part of the questionnaire focused on whether students liked the after-school assignments. Everyone could preview them and cooperate with the group members to prepare a weekly report. It also focused on whether students felt that the peer interaction and learning quality improved. The second part focused on whether students felt that weekly previews and reports helped them better clarify and understand concepts of the course and improve their cognitive levels and abilities to solve problems.

The third part focused on students' views of the hands-on practice of LabView, i.e., whether it helped them learn content of the course and increase their practical experience. The fourth part focused on the mode of the project report, i.e., whether it helped them improve their problem-solving skills and solve problems. The fifth part focused on whether students felt that the homework of LabView can help them think and develop higher cognitive levels and whether they have learned different solutions and generated more ideas from the report. In the sixth part, we also explored whether students were still willing

to participate in similar teaching courses. The last item was an open-ended question, and the students were asked to write down any experienced issues associated with our instructional approach. The questionnaire scores of the first six parts were calculated by using a five-point Likert scale.

Interviews with students were also carried out. In the interviews, the students were asked about their learning experiences. The interviews' data were recorded, transcribed, and coded following the grounded theory design [21].

4. Results and Discussion

4.1. Study 1

Although we incorporated the flipped classroom and project-based learning approaches, our results showed that the students were not familiar with the simulation tools and lacked PBL experience. In addition, a large number of algorithmic theories caused students to spend more time on understanding the course content, and the results of the analysis showed that their six cognitive levels were more distributed in understanding, application of software, and analysis of data cognitive levels. There was not enough time for students to have more growth at other higher cognitive levels and to design and produce more innovative projects.

4.1.1. Weekly Preview and Report

After six weekly previews and reports, we analyzed the distribution trend of each cognitive level in sequence (see Figure 4). According to the figure, students' cognitive level was distributed more in the understand and analyze levels. That is, students were more focused on understanding theoretical concepts by finding related information and then discussing and analyzing it with other students.

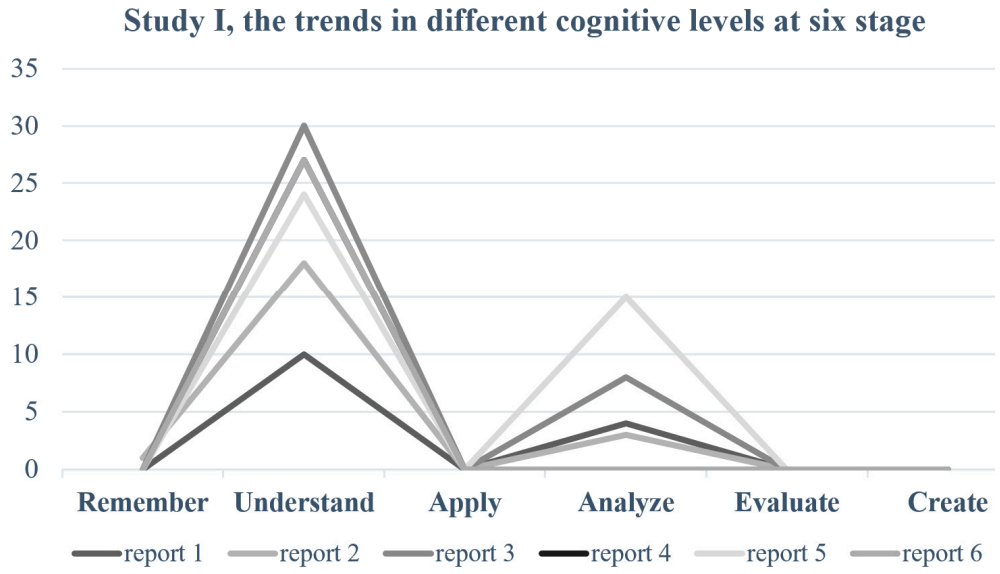

Figure 4. The trends in different cognitive levels at six stages.

4.1.2. Weekly Homework

Figure 5 shows the results of the cognitive-level evaluation in regard to homework. According to the results, the trend of cognitive level distribution for the understand, apply, and analyze levels was declining. The reason was because the theory of the course content was becoming more difficult. Students mentioned several reasons to explain this finding (see Appendix A).

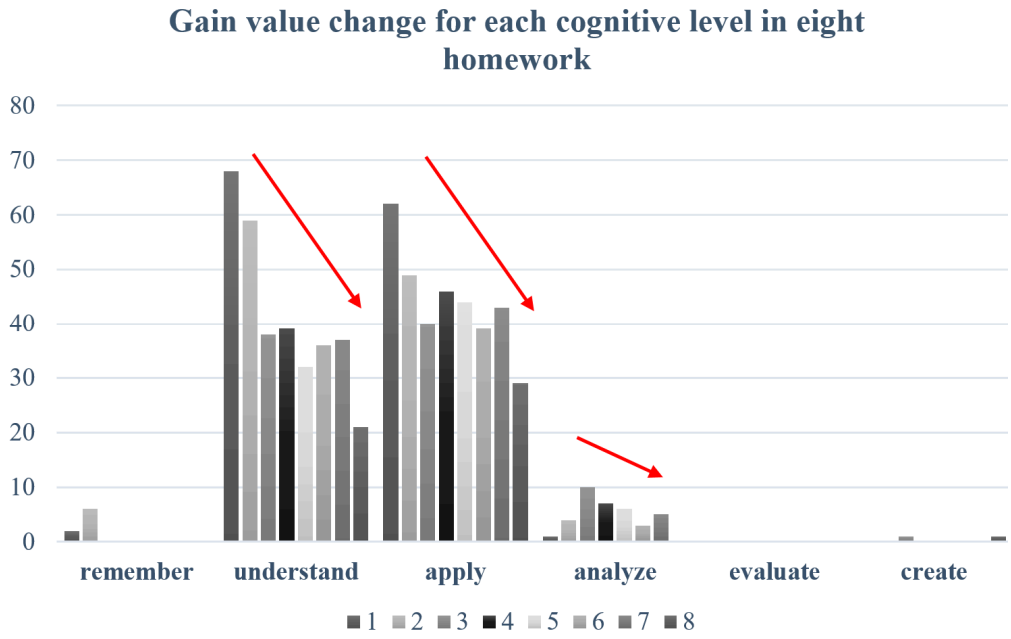

Figure 5. Gain value change for each cognitive level in homework (red arrows demonstrate declining trend).

In addition, we found that there was no significant change between the evaluate and create levels of cognition. Therefore, this part of the phenomenon and corresponding reason was one of the focuses of our Study 2 on the adjustment strategy.

4.1.3. Monthly Project Report

The trend of cognitive level change in each reporting stage is shown in Figure 6. From these data, we can observe that the cognitive level related to the understand, apply, and analyze levels improved during the course. However, there was no change in such cognitive levels as evaluate and create. Because these are the highest cognitive levels and very important for learning, in Study 2, we focused on enhancing them.

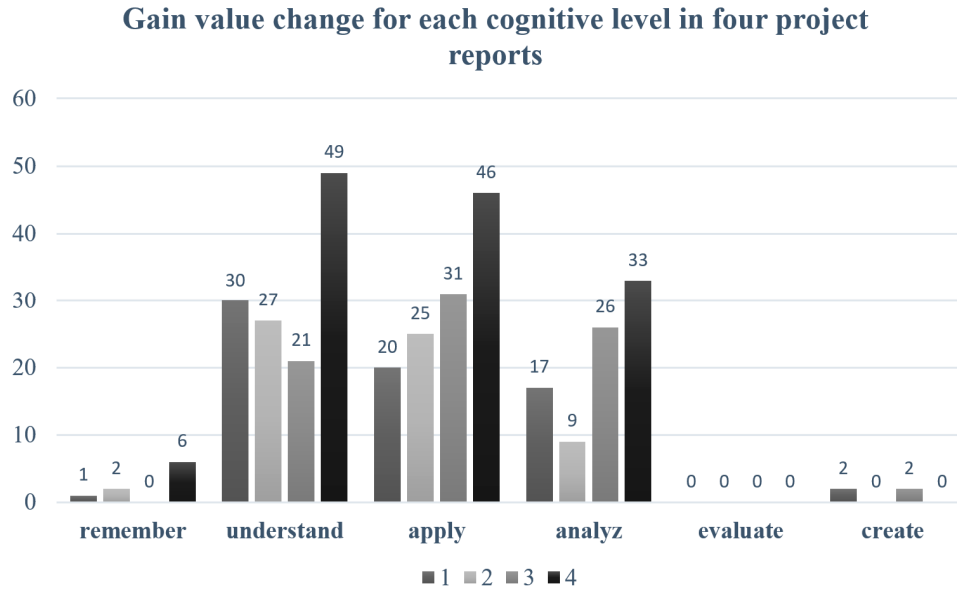

Figure 6. Gain value change for each cognitive level in four project reports.

4.1.4. A Post-Test Questionnaire from Study 1

The score of the questionnaire was 3.97 points, indicating that the students agreed that the course was helpful and that they liked it. However, student answers to an open-ended question showed that there was still considerable space for improvement. Some extracts from interviews with students are reported in Appendix A.

4.1.5. Other Findings

Weekly homework and monthly project reports require a lot of time to prepare. Monthly project reports affect students' performance more compared to weekly homework; however, students have to spend more time on monthly project reports than on weekly homework.

4.2. Study 2

Based on the results from Study 1, we modified our instructional approach by incorporating reciprocal teaching activities in Study 2. We grouped the students based on their leadership and creative styles in order to improve their abilities and facilitate their high cognitive levels. For example, students can learn new knowledge and then apply it to solve real-life problems.

4.2.1. Weekly Preview and Report

The instructor guided students to explore assigned problems. In addition, the instructor helped students understand the learning content and key points of the course. The interview results showed that this kind of teaching mode could promote students' active thinking and self-learning and also enhanced learning motivation, learning attitude, and communication ability. We provide some excerpts from the interviews in Appendix A.

Figure 7 shows the number of cognitive levels in each weekly preview and report. According to the figure, the understand part of the cognitive level greatly improved over time. In addition, the analyze and evaluate levels, which are higher cognitive levels, emerged.

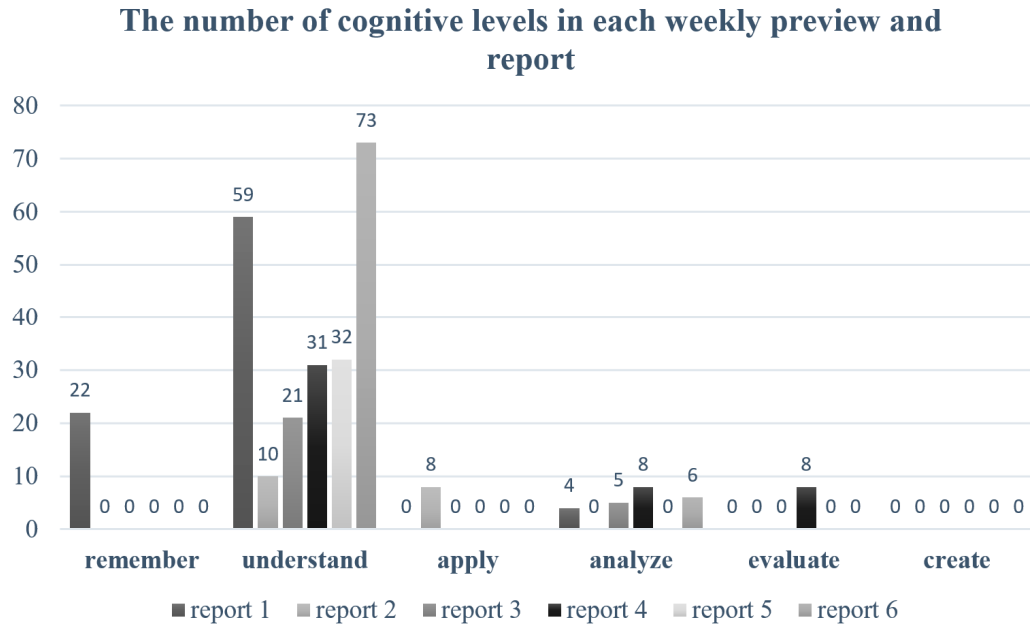

Figure 7. The number of cognitive levels in each weekly preview and report.

Figure 8 presents trends in different cognitive levels. According to the figure, fluctuations in cognitive levels evolve from low cognitive levels (on the left side) to high cognitive levels (on the right side). The experiment was not long enough (i.e., only 18 weeks), and so time was not sufficient for the students to improve their professional knowledge and ability.

We suggest that students need long-term exposure and that the educators and researchers can perform similar studies in the future which could last at least one year. As a result, the change trend of cognitive levels can obviously advance, i.e., higher frequency of high cognitive levels, such as evaluate and create.

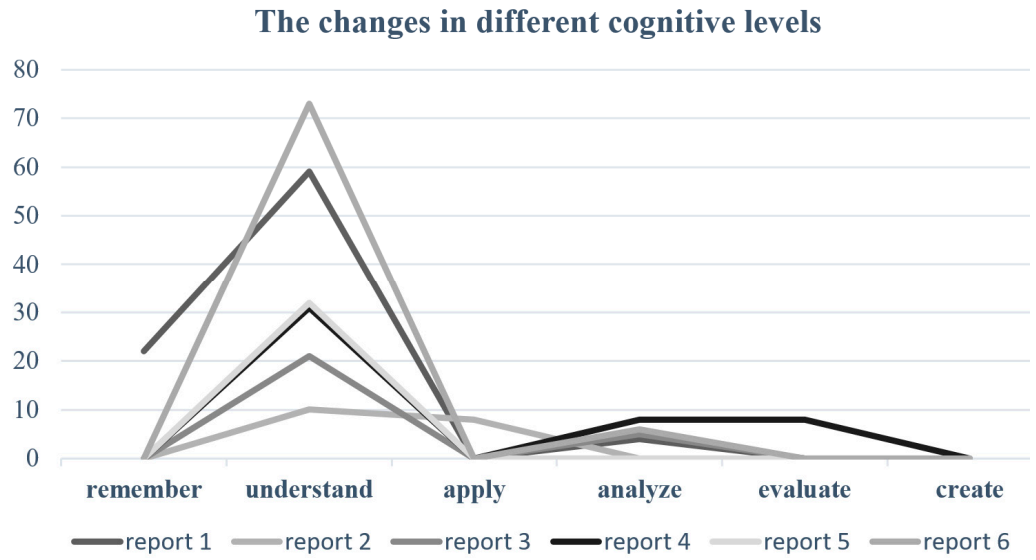

Figure 8. The changes in different cognitive levels.

4.2.2. Reciprocal Teaching Activity

In interviews, the students mentioned that they felt that, through this activity, they could train their teamwork, expression ability, leadership, understanding of content, and active thinking. In this way, their understanding of professional knowledge became more thorough and substantial, and the students could quickly review the content of the course again and deepen their memory. Furthermore, after discussing with each other, the students could also learn the methods that they have never thought of from different perspectives. Student opinions from interview are provided in Appendix A.

Figure 9 shows the frequency of different cognitive levels in each activity. According to the figure, as the course progresses, changes in the understand level's frequency from the first to the fifth activities decreased; however, it is the highest in the last activity. In the following, we provide some possible reasons. First, in the learning process, the algorithm architecture is a difficult and complex concept, so the interpretation, examples, discrimination, narrative, and interpretation that students can put forward on the theme of the algorithm are gradually reduced. Therefore, the change in the understand level throughout the activities declined. Second, the understand level in the last activity is the highest because of the subject matter of the discussion. That is, the students learned about algorithms related to signal processing of power quality disturbances in the first five activities; however, they judged power events in the last one, so it was easier for the students to identify, describe, and explain related concepts.

After comparing Figure 7 with Figure 9, it is observed that, in the learning process, there is a negative correlation between the understand level in the two figures, and the trend changes between "weekly preview and report" and "reciprocal teaching activity" are reversed (i.e., from the second activity to the fifth one). The important reason to explain this finding is that in terms of the "weekly preview and report", the students had more time to work and prepare it, but for the "reciprocal teaching activity", the students had less time to discuss and think about related concepts. Furthermore, although the frequency of the understand level in reciprocal teaching activities is less than in weekly preview and reports, "reciprocal teaching activity" can complement "weekly preview and report", thus, allowing learners to explore more different dimensions that were not found in the weekly preview and reports. The frequency of the understand level in "reciprocal teaching activities" may

be because the contents of the gain values were not included in the "weekly preview and reports", as shown in the figure.

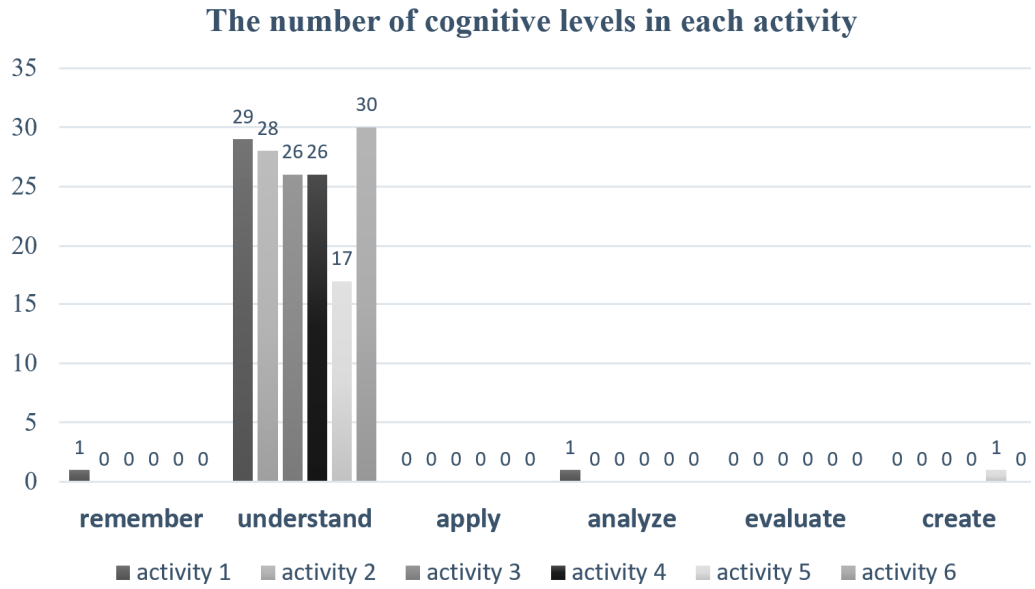

Figure 9. The number of cognitive levels in each activity.

4.2.3. Hands-On Practice Using LabView

In engineering education, hands-on practice plays a very important role. Hands-on practice not only extends and deepens the learning experience but also cultivates the ability to think critically and solve problems. More importantly, hands-on practice improves the cognitive level of learners. According to the curriculum, students are required to practice on LabView. If there is any problem in the process, students can raise their hands to ask for help from the teacher. Student opinions are provided in Appendix A.

Students have sufficient time in three classes to perform and operate the LabView. The teacher was there to assist them. Hands-on practices of LabView helped students validate and consolidate the knowledge concepts of the course. After practical experience, students were also able to reach such a high cognitive level as the apply and analyze levels.

4.2.4. Homework

Although the teacher's guidance and peer-to-peer interaction in the classroom can be used to stimulate the students' higher cognitive level, a low cognitive level was still seen in the majority. This suggests that these teaching strategies and the course design in the classroom were not enough to facilitate higher cognitive levels in engineering education. Therefore, we added another hands-on practice course of LabView and the practical assignments to the students, so that the students could practice after class. There were five assignments in total. The first four were the implementation of the algorithm from the simple to the hard, and the fifth one was to judge and implement the power quality event.

According to Figure 10, it can be found that the statistical chart is different from that of the weekly preview and reports and reciprocal teaching activities. In addition to the understand level, other high cognitive levels, i.e., apply and analyze, showed significant growth. However, the growth of the create level is not obvious, but it also appears as a sprout. Our results suggest that high cognitive levels need to be developed step by step through the process of training, brewing, fermentation, and then maturity. Although we added hands-on practice in the classroom and practical homework to cultivate students' ability, the teaching time (18 weeks) was not sufficient enough. In addition, it is necessary to administer diverse teaching activities and content to help students develop their higher cognitive abilities.

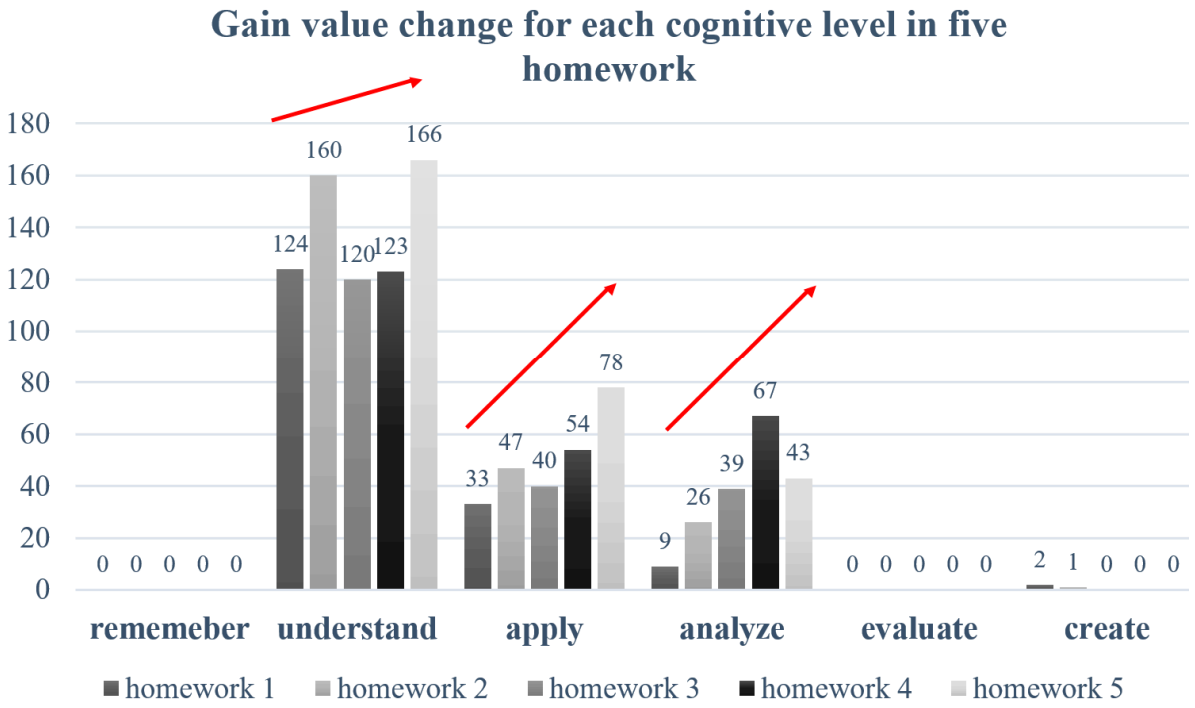

Figure 10. Gain value change for each cognitive level in five homework assignments (red arrows demonstrate rising trend).

4.2.5. Monthly Project Report

It can be found from Figure 11 that the gain value of the cognitive levels related to the second report is lower than that of others. This result may be due to the longer preparation time and more sufficient content and information in the first report. In addition, the report content was also reduced because the time interval of the second report with the first report was only three weeks, which was not enough. Another reason may be that the algorithm of the second report was more difficult, and the theory was constructed in the previous report. The students needed to spend more time on learning, understanding, implementing, verifying, and preparing reports so that the changes of the gain value at all cognitive levels were lessened in a short preparation time. In the third report, the analyze cognitive level was greatly improved because, after the implementation and application, the students needed to analyze, judge, and describe the information obtained. In addition, we could find that, through the project report method, the students' cognitive abilities not only remained in the remember or understand levels (see Figure 11) but also reached higher levels, such as apply and analyze.

According to the questionnaire and interview survey, more than 70% of the students agreed that they were active and willing to explain the results and share experiences with others in the project report. Student opinions are provided in Appendix A.

The instructional approach was student-centered, the learners discussed the projects with each other, and the teacher guided them at the right time when they became confused about some concepts. Such an approach enhanced the development of higher cognitive levels of the students, helping them achieve sustainable learning practices when compared to the traditional teaching approach.

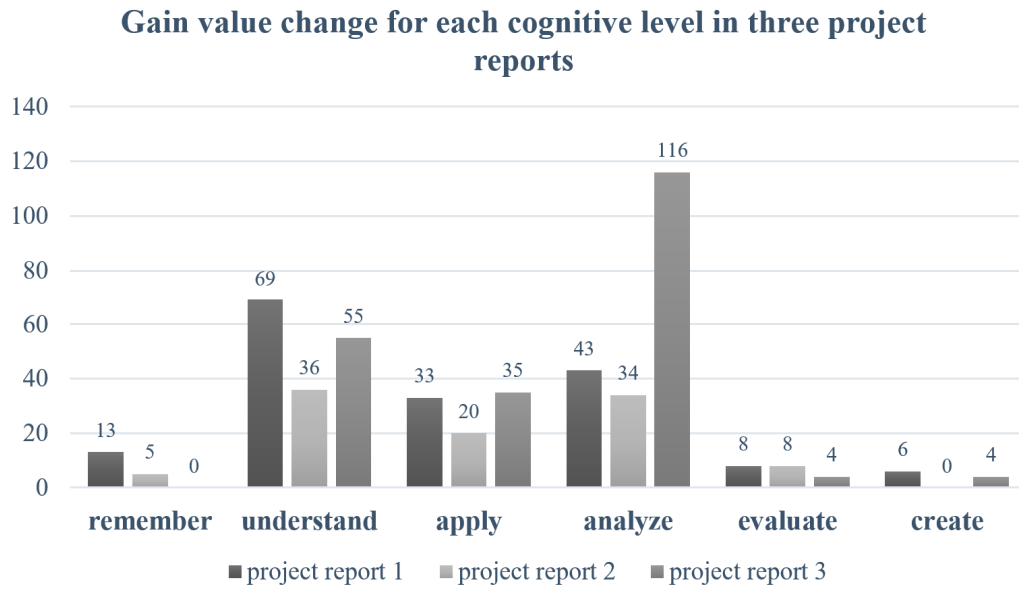

Figure 11. Gain value change for each cognitive level in three project reports.

4.2.6. Interview Results

From the interviews, we aimed to gain a deeper understanding of the students' experiences and obtain their suggestions. In the simulation of LabView, the students believed that, through implementation, they could be clearer about the application. When they achieved the goals, they could also have a great accomplishment and enhance the ability to express and work with the team. However, there were a few cross-disciplinary students who had also taken this course. Because LabView was not used normally for them, they believed that they were more passive in learning, and their achievement and satisfaction were relatively low. However, with the application of LabView, most of the students believed that they could learn the abnormal conditions of various power systems, the types of power quality events, and how to use different methods to do the test. They also had a better concept of and improvement on signal analysis. The students no longer just engaged in empty talk.

In the reciprocal teaching activities, the students could stimulate the thinking ability of each other through joint problem-solving. Some students also indicated that, because of their lack of knowledge in this field, it was relatively difficult to lead the group to discuss and analyze the problem. In this course mode, the students could stimulate their high-level thinking; develop their understanding of the application, details, and problems of the implementation; improve on the lack of theory; and increase their own ideas.

In the heterogeneous grouping of leadership and creativity styles, in addition to increasing the students' sense of responsibility for the supervision of the group's progress, the leader's influence on the learning among the members of the group was not obvious. From the students' responses, it could be found that the professional ability and the prior knowledge of the members occasionally revealed the gaps between each other; therefore, all contribution of the group often fell on the same students. How to make the students in the group help improve each other's abilities becomes an issue worth investigating. Finally, the students felt that the teacher could have the interactions and communicate with them during the free time of teaching, making them feel more likely to learn the content of the class and feel fulfilled.

4.3. Comparison between Study 1 and Study 2

We compared the results from Study 1 with those obtained in Study 2 (Table 1). The create level was the highest cognitive level, as it could help students develop their abilities on the creative dimension. However, as teachers, we need to be aware of the level of cognition of each activity in the course arrangement so that we can ensure that students are given a diverse curriculum experience and help them to promote higher-level thinking.

There is one thing which is very important and must not be ignored—if students do not have the lower level of cognitive skills, such as remember and understand, then they are not able to remember and understand what they have learned in the course. In that kind of situation, they are unlikely to apply what they have learned to the new environment, and there is no need to further analyze, evaluate, and develop products and generate new ideas through learning.

Table 1. Comparison between Study 1 and Study 2.

Items	Study 1	Study 2
Group mode	Free grouping	Heterogeneous grouping (leadership and creative style)
Weekly preview and reports	Cognitive level represented understand and analyze levels; There was lack of interaction time with teachers.	Adding reciprocal teaching activities lead to gradual development of higher cognitive levels; The students had more time for interaction with teachers.
Homework	Once a week; The students felt burdened and time-consuming; The cognitive level represented understand and apply; Cognitive level frequency decreased over time.	Once in two weeks; Through flexible adjustment, the students were able to coordinate activities easier and further study; The cognitive level reached understand, apply, and analyze; Cognitive level frequency increased over time.
Monthly project reports	Four times; The schedule was more compact; The content repetition rate was high; Higher cognitive level frequency had no obvious change.	Three times; The schedule was more flexible; Hands-on practice; Higher cognitive level frequency had obvious change.
Advantages and disadvantages	The students cannot practice in class; Compact course activities and progress; The students had no improvement in high cognitive levels.	The hands-on practice activity was introduced; Flexible curriculum activities and schedule design; The students had improvement in high cognitive levels.

As the old saying goes, "The nine-story platform starts from the soil" and "the high-rise building starts from the ground." Therefore, we use the project-based learning approach as the core of the two studies, and we also introduce the flipped classroom and the reciprocal teaching activities to the students to increase their mastery of the course content. In addition, the hands-on practice was implemented in order to develop student application and analytical skills. Meanwhile, we guided the students to reach high cognitive levels in this study.

In Study 2, the students had more interaction time in reciprocal teaching activities, although the teacher's teaching time was reduced, but relatively, there were more opportunities for the teacher to observe the student interaction. The teacher could approach different groups to observe whether there was good discussion, and then the teacher could also join the students in a timely manner to help them solve the problems and correct their mistakes. The teacher could also adjust the pace of teaching so that the teacher and the students had good interactions.

In Study 2, the weekly preview and reports still brought an additional course burden. Through the students' responses in the classroom, the teacher adjusted the teaching progress and content in time to meet the students' learning pace. Moreover, the curriculum load was reduced.

In addition, the hands-on practice of Study 1 was mostly executed after class, so it was impossible to strike while the iron was hot. We found student feedback in Study 1 showing that the students hoped to have direct practice drills in the classroom. After that, we observed the difference between Study 1 and Study 2 in the classroom, and we found that the hands-on practice time of the classroom of Study 2 was more about half than that of Study 1. This improved the students' application ability. In Study 2, the teacher also asked the assistant to teach the students LabView software so that students became familiar with the tool faster and achieved their learning goal faster.

The reciprocal teaching activities had more advanced or professional discussion, which improved the students' higher cognitive levels. Although the teacher's teaching time was shortened, the teacher's role and position were changed to that of expert and consultant. Additionally, at the part of the homework, the students increased the experience and ability

of practical operations by doing, so that students no longer thought about how to complete the project and do the surface work.

4.3.1. Weekly Preview and Report

Study 1 and Study 2 both contained six weekly previews and reports. We encoded each weekly preview and report and then compared. An independent t-test was used to explore the differences between Study 1 and Study 2. Results are reported in Table 2. It was found that there was no significant difference between Study 1 and Study 2 in each cognitive level. The reason for such a finding can be discerned from Figures 4 and 7. In the two studies, the most frequent cognitive level is the understand level in weekly preview and reports because the teacher provided a new question right before weekly preview and reports. The learning content was new for the students, so that they spent a lot of time exploring and understanding it. The frequency of other levels was low because higher cognitive levels could not be improved until the students understood new learning content well. Therefore, there is no significant difference at each cognitive level in the weekly previews and reports of two studies.

Table 2. Cognitive levels assessment of weekly preview and reports of Study 1 and Study 2 and their comparison.

Cognitive Levels	Group	Mean	SD	*t*-Value	*p*-Value
Remember	Study 1 Study 2	0.17 3.67	0.408 8.981	−0.954	0.384
Understand	Study 1 Study 2	22.67 37.67	7.421 23.763	−1.476	0.191
Apply	Study 1 Study 2	0 1.33	0 3.266	−1.000	0.363
Analyze	Study 1 Study 2	5 3.83	5.727 3.251	0.434	0.674
Evaluate	Study 1 Study 2	0 1.33	0 3.266	−1.000	0.363
Create	Study 1 Study 2	0 0	0 0		

However, when we compare two figures (i.e., Figures 4 and 7), we can find that the development of the remember, understand, apply, and evaluate levels in Study 2 are better compared to those in Study 1. This is due to adjustments in teaching strategies and new curriculum arrangements which gradually stimulated students' development in other cognitive abilities.

In order to improve higher cognitive levels in weekly previews and reports, the instructors may consider changing the nature of the assigned weekly preview and reports [28–31]. Initially, the students were asked to preview learning content before class and summarize their ideas in weekly previews and reports. Perhaps, in addition to this task, the instructors may ask the students to explain how newly learned knowledge can be applied to a different context (the apply level) or when the students are asked to check the weekly previews and reports of their peers, they may try to evaluate content and report their evaluation results, along with their feedback and ideas related to presentations (evaluate).

4.3.2. Homework

The results of the t-test to compare cognitive levels of homework in Study 1 and Study 2 are reported in Table 3. According to the results, the frequency of the remember level in Study 1 is significantly higher than that in Study 2 ($t = 7.515$; $p = 0.000 < 0.05$). However, the frequency of the understand level in Study 2 is significantly higher than that

in Study 1 (t = −2.244; $p = 0.046 < 0.05$). Furthermore, the frequency of the create level in Study 2 is also significantly higher than that in Study 1 (t = −5.842; $p = 0.000 < 0.05$).

Table 3. Cognitive levels assessment of homework of Study 1 and Study 2 and their comparison.

Cognitive Levels	Group	Mean	SD	*t*-Value	*p*-Value
Remember	Study 1	7.25	2.121	7.515	0.000 *
	Study 2	0.00	0.000		
Understand	Study 1	213.88	90.802	−2.244	0.046 *
	Study 2	406.40	218.759		
Apply	Study 1	214.63	102.802	1.503	0.161
	Study 2	131.80	84.872		
Analyze	Study 1	21.75	13.562	−2.028	0.110
	Study 2	88.60	72.920		
Evaluate	Study 1	0.00	0.000		
	Study 2	0.00	0.000		
Create	Study 1	0.88	0.641	−5.842	0.000 *
	Study 2	2.80	0.447		

* $p < 0.05$.

To explain these results, we need to refer to Figures 6 and 11. From the figures, we can find that cognitive level of the students rarely reaches low levels such as remember in Study 2. For this reason, the frequency of remember level in Study 1 is significantly higher than that in Study 2. However, the frequency of other levels of cognition such as understand and create, which are higher than remember, are higher in Study 2 compared to Study 1. Higher levels of cognition represent that students are more proactive in thinking and generating new ideas in Study 2 than Study 1. Interviews results from students after Study 2 can also support our findings (see Appendix A).

Our results show that intervention in Study 2 could facilitate the understand cognitive level. That is, students were able to understand their homework assignment better because of the hands-on practice in Study 2. The interview data also support this result (see Appendix A).

About the frequency of the create cognitive level, it was significantly higher in Study 2 than in Study 1. This result also proves that the intervention of Study 2 was indeed more useful to facilitate higher cognitive levels (i.e., create) than of Study 1. It also shows the success of Study 2 in teaching strategies and curriculum adjustment. Interview excerpts are provided in Appendix A.

4.3.3. Monthly Project Report

The results of the monthly project report evaluation are included in Table 4. In addition, it includes the results of the independent t-test, which was used to compare cognitive level of students in Study 1 and Study 2. According to the results, the frequency of evaluation levels in Study 2 was significantly higher than that in Study 1 (t = −5.000; $p = 0.038 < 0.05$). From Figure 6 and Table 4, we can find that students did not reach the evaluate level in Study 1. In contrast, in Study 2, the students in each group could gradually judge and comment on different power quality events in the monthly project report according to the algorithm specifications, experience, and standards. This is the reason that explains the difference between two studies.

The data show that there was no significant difference in other cognitive levels between Study 1 and Study 2 (see Table 4). However, when referring to Figures 6 and 11, it can be found that the students had more instances of higher cognitive levels (i.e., analyze, evaluate, and create) in Study 2 than in Study 1. The results suggest that the course mode, the guidance of the teacher, and the strategies arrangement of Study 2 were obviously beneficial to promote the students' higher cognitive levels. Some objective evidence to support the results was derived from the interviews after Study 2 (see Appendix A).

Table 4. Cognitive levels assessment of monthly preview and reports of Study 1 and Study 2 and their comparison.

Cognitive Levels	Group	Mean	SD	*t*-Value	*p*-Value
Remember	Study 1	2.2500	2.62996	−1.063	0.337
	Study 2	6.0000	6.55744		
Understand	Study 1	31.7500	12.09339	−2.011	0.101
	Study 2	53.3333	16.56301		
Apply	Study 1	30.5000	11.26943	0.151	0.886
	Study 2	29.3333	8.14453		
Analyze	Study 1	21.2500	10.46821	−1.627	0.236
	Study 2	64.3333	44.97036		
Evaluate	Study 1	0.0000	0.00000	−5.000	0.038 *
	Study 2	6.6667	2.30940		
Create	Study 1	1.0000	1.15470	−1.435	0.211
	Study 2	3.3333	3.05505		

* $p < 0.05$.

4.3.4. Learning Outcomes

The students' learning outcomes in Study 1 and Study 2 are represented by the scores of their final projects. We used the independent t-test to compare learning outcome between Study 1 and Study 2. As shown in Table 5, the learning outcomes in Study 2 were significantly better than in Study 1 ($t = -3.270$, $p = 0.004 < 0.05$). This proves that the teaching strategies in Study 2 impacted student learning outcomes positively so that the student cognitive level improved. Some evidence was obtained from interviews with the students after Study 2 (see Appendix A).

Table 5. The independent t-test for the learning outcomes between Study 1 and Study 2.

Study Number	Mean	SD	*t*-Value	*p*-Value
Study 1	88.83	1.749	−3.270	0.004 *
Study 2	90.80	1.033		

* $p < 0.05$.

In order to consider that the students' prior knowledge may have an impact on the learning outcomes, we also interviewed the instructor. The excerpts from the interview with the teacher are provided in Appendix A.

Based on the evidence from the interview, we can exclude the uncertain factors of the prior knowledge and ensure that learning outcomes were influenced by the teaching strategies, the guidance of the teacher, and the curriculum arrangement in Study 2.

The results demonstrate that various instructional strategies were beneficial for students in their learning. For example, in flipped classroom, students can prepare for their class at home and then spend class time on discussing new concepts they leaned [7]. Instructors then can easily identify student difficulties and misconceptions [8]. Project-based learning enabled students to identify the problem and then try to solve it in collaboration with other students [12,13]. Such an approach created authentic learning contexts in which problems students dealt with were those that they likely to experience in the real world [9,11]. The reciprocal teaching approach enabled students to become a teacher in a small group [16]. A student-teacher then guided group discussions using various strategies, e.g., summarizing, question generating, clarifying, and predicting [18]. All of these approaches were employed in the study to ensure student-centered learning, the interaction between the teacher and students, and the facilitation of cognitive levels. We found that flipped classroom and project-based learning had an impact on the cognitive-level development, especially on the understand and analyze levels. However, when reciprocal teaching was introduced, other cognitive levels improved as well, e.g., apply and analyze.

Based on our results, we suggest that diverse instructional approaches need to be implemented. Our results demonstrated that students did not have sufficient time in this course to master their professional knowledge and abilities. Therefore, we also suggest that the intervention last longer, e.g., one academic year. In this case, students will have long-term exposure to the treatment, and their cognitive abilities, such as various levels of cognition, can be developed diversely and become even better. From the results, we also found the importance of hands-on experience. Therefore, we suggest that students have hands-on experience (e.g., to perform and operate LabView) and sufficient time for practicing their skills so that their knowledge and skills can be validated and consolidated. We also suggest that the role of the teacher is important in the learning process when various instructional approaches are implemented (flipped classroom, project-based learning, and reciprocal teaching). The instructor can observe the learning process and interaction among students and intervene, when necessary, by assisting, guiding, and providing feedback to students when they experience any difficulties.

Some limitations regarding the present study need to be acknowledged. First, a small number of students participated in the study, and it was carried out over a limited period of time. Therefore, the findings of the present study need to be interpreted with caution. Another limitation is that all participants of the study were males, and this is because there are not so many female students who study electrical engineering. Future studies may consider increasing the number of their participants, carrying out their studies for a longer period of time, and considering involving female participants as well. Future studies may also consider exploring other research variables that may provide evidence for effective applications of reciprocal teaching in the flipped classroom to facilitate a high level of cognition for sustainable learning practices. For example, learning behavior and interaction among participants can be explored deeper, as well as employing path analysis to investigate common patterns in learning behavior and interaction during reciprocal teaching in the flipped classroom.

5. Conclusions

In the traditional classroom, students only listen to the teacher's lecture. We incorporated the flipped classroom strategy with weekly previews and reports to assist students to learn actively, PBL to help students have more ideas of learning by doing and strengthen their team works, and reciprocal teaching strategy to promote their collaboration and presentation skills. These approaches were applied to create a learner-centered environment and enhance students' cognitive skills toward professional knowledge from the basic-understanding cognitive level to higher cognitive levels, i.e., analyze, evaluate, and create. PBL and weekly previews and reports helped students preview what they learned and find and solve problems independently; hence, when the students achieved the learning goal, they felt satisfied. In addition, our approach was useful to improve their motivation to learn more.

In Study 2, we used student leadership and creativity abilities to group them heterogeneously. We found that it was helpful, as the students' higher levels of cognitive skills were improved, and it helped achieve sustainable learning practices. In the future, we may also consider other demographic factors, such as students' personality, background knowledge, expertise, etc.

Because students perceived that their learning load was heavy in Study 1, the teacher adjusted the class schedule promptly and reduced the homework amount to fit the curriculum to their needs and capacity in Study 2. Therefore, in Study 2, the students learned based on their paths. Our results showed that the students were pleased and satisfied with this course.

Author Contributions: Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing—original draft preparation, W.-Y.H. and T.-H.W.; validation, writing—review and editing, correspondence, R.S.; supervision, funding acquisition, W.-Y.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partly funded by 109-2511-H-008-009-MY3 and 111-2410-H-008-061-MY3, National Science and Technology Council, Taiwan.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Graduate Institute of Network Learning Technology at the National Central University for studies involving humans.

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

Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to restrictions such as privacy and ethical reasons.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Extracts from interviews with students:

About Homework

"Every week we have homework, I feel it is too burdened and time is tight, but I still find the course design very helpful."

"It takes a considerable amount of time from the understanding of the algorithm to the actual test."

"The implementation software may require additional teaching and assistance, plus the preparation for flipped reports and project reports, which often causes the progress of the work not easy to keep up."

About Study 1

"Weekly preview and report helped us better understand the content of the course, and we could also know the advantages and disadvantages of various methods and applications in advance. The most important thing was that I think the implementation made me more conceptual about the content of the course."

"I suggest that if we can take this course in the computer classroom, it can help us improve the application skills and project completion of LabView software."

"These teaching strategies have prompted us to complete the preview. Students need to find information to understand it, we can't just blindly memorize the formula and don't know how to apply it. I am very fulfilled in this course. (I feel that the all practical classes will also give us a sense of accomplishment, and the different part of this class is not just to follow the experimental steps but to know what we are doing)."

About Weekly Preview and Report

"The learning ability has been greatly improved and it can be applied continuously."

"I have learned how to interact and collaborate with group members."

"No matter knowledge or expression ability, I have a big harvest."

About Reciprocal Teaching Activity

"After group discussions, we can better understand the curriculum and enhance our ability to express."

"There is more opportunity and time to ask questions and discuss."

About Hands-On Practice using LabView

"The hands-on practice is like experimenting in general. If we encounter problems, we could think about how to solve them by ourselves. If we don't know how to solve them, we just raise our hand to ask the teacher."

About Monthly Project Report

"Increasing opportunities to communicate with colleagues."

"We could improve each other's content during the discussion."

About Homework

"This learning model is easier for us to understand what we have learned and how it is applied."

"After understanding the theory, we will improve the areas where the theory is insufficient and increase our own ideas."

"It can help us to understand the content of the class easier."

"When we finish our homework, we will feel fulfilled."

"Through the hands-on practice, we can understand the theory of the application more clearly. And when we finish the implementation of LabView, we will feel fulfilled."

"Sometimes when I do some homework, I will recall I might have ever learned it in class before, and I just know what the teacher taught us at that time, so it will make me extend different ideas."

"I have other insights and innovative ideas for the application of the test methods, and they are applied to the project."

"In this way of learning, it let me know how to apply various methods."

"Under this learning mechanism, every time is to break through myself."

About Monthly Project Report

"The teacher explained the course content clearly and he answered questions I don't understand."

"I like this way of class. I will preview the course content before class. In this way, I can know the content first before the teacher teach us and help myself to understand the content better. And I will not feel so hard to understand when we start class, and the teacher will give us time to practice in the classroom and allow us to have time to discuss with each other, so that I can clearly understand the theory of the implementation, and finally we can share our ideas between groups. The new ideas and methods are very helpful."

"It let me learn a lot of things from the preview discussion and the review discussion."

About Learning Outcomes

"I want to score this class more than 100 points. The teacher discussed with the students in addition to teaching, so that we could more easily absorb the content of the class."

"I think this class was very good and want to recommend everyone to study. I have learned a lot in this course and it was very helpful to me. Thanks the teacher for teaching and hard work this semester, thank you so much!"

"This class had more hands-on practice than the general theoretical course. Fortunately, the teacher adjusted the teaching strategies of the course, otherwise the load was very heavy in class; because I wanted to learn the theoretical basis originally, and I did not expect that we will have hands-on practice. The ability of the teacher and classmates made me want to strengthen my ability. Although the things I usually study are less relevant to this course, I tried to integrate what I have learned in this course into my own research in the future."

"This course is for the master degree students. The students have learned about engineering mathematics, signal and system courses at the university, so they have the prior knowledge, and if they have not learned about relevant course in this fields from their

universities, and they do not need to worry about it, because when we explain the relevant knowledge and skills in the classroom, and these things are introduced from the basics, it is not difficult to get started, and it is not affected by the prior knowledge."

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A Bibliometric Analysis of Trending Mobile Teaching and Learning Research from the Social Sciences

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Abstract: With the development of computer and information technology, mobile teaching has enjoyed pride of place among teaching mediums in the past two decades. To visually explore the mobile learning hotspots and trends present in international journals, this study adopted two science mapping tools (CiteSpace and VOSviewer) to first detect and then visualise emerging trends (i.e., hotspots) in the mobile learning literature. A total of 528 mobile learning articles published between 2003 and 2021 that appeared in 21 international educational technology journals indexed in the SSCI database were retrieved for bibliometric analysis. The results show (1) there was a remarkable increase in academic output in this field starting in 2008 that topped out in 2021; (2) co-authorship with academics from diverse countries/regions and institutions was evident; (3) three trending foci in the literature include defining mobile learning, designing learning systems, and exploring mobile learning effectiveness; and (4) the high-frequency co-cited publications focus on the effectiveness of mobile devices via different research methods. This study provides scholars with an accessible summary of the current trends in mobile learning, identifies the active researchers in this field, and reports on which outlets are most relevant for research produced on this topic. In addition, the findings have direct implications for the education and private sectors. Mobile devices are not widely adopted in classroom settings and are often considered a learning tool more suited for out-of-class assignments or practice. Therefore, it is necessary for information technology educators to invest in actively initiating the integration of mobile technology into the classroom. Those in the technology industry should aim to develop mobile devices and relevant educational applications/software that can be utilised not only within the confines of the classroom but also to bridge in-class and out-of-class learning.

Keywords: mobile teaching; mobile learning; CiteSpace; VOSviewer; SSCI; bibliometric analysis

Citation: Fan, C.W.; Lin, J.; Reynolds, B.L. A Bibliometric Analysis of Trending Mobile Teaching and Learning Research from the Social Sciences. *Sustainability* **2023**, *15*, 6143. https://doi.org/10.3390/su15076143

Academic Editor: Massimo Aria

Received: 5 December 2022
Revised: 16 March 2023
Accepted: 27 March 2023
Published: 3 April 2023

1. Introduction

Technology, especially mobile technology, has played an essential role in students' learning process during the COVID-19 pandemic. According to technologists, mobile learning involves learning on a mobile device (e.g., tablet, mobile phone, laptop) [1]. Additionally, mobile learning is considered a continuation of e-learning. In learner-centred theory, it is believed that mobile technologies allow students to learn in a constantly changing and nondeterministic environment to maximise learning opportunities [2]. As part of school education, mobile learning has changed in several ways: (1) the way teaching content is presented; (2) how students learn; (3) the methods teachers use to teach; and (4) the way students interact with teachers [3]. Mobile learning has established itself as a common phenomenon in educational pedagogy that has received widespread attention from educators and researchers.

Mobile learning research originated at the end of the 20th century. Researchers have extensively studied this field over the past two decades, providing insights into theory and practice. After many researchers have studied mobile learning from various perspectives,

some researchers pointed out the need to review the literature in this field. One good example is Wu et al. [4], who conducted a meta-analysis of 164 mobile learning studies from 2003 to 2010. Their results showed that mobile learning effectiveness and system design are primary research areas, with system design having dominated the research trajectory. Besides meta-analysis, bibliometric analysis is also a common method to study this field's literature. For example, Khan and Gupta [5] conducted a bibliometric analysis of mobile learning research from a student-centred perspective. According to co-citation analysis of 722 articles, four clusters (concept, application in education, designing framework for model learning/acceptance, and emerging technologies) of hotspots were identified. In a similar vein, Goksu [6] analysed 5167 mobile learning articles published until September 2019. The study uncovered mobile learning research trends. They found the researchers coming from Taiwan, USA, Mainland China, and England were the most productive with Taiwan responsible for the lion's share of research produced. In addition, the single university producing the most research in this area was also in Taiwan. Lastly, keyword co-occurrence analysis showed mobile devices, higher education, mobile technologies, tablet, and smartphone as high frequency keywords in this field.

Due to its high functionality, CiteSpace has been the go-to software of bibliometric analysis conducted by Chinese scholars [7–9] but has been utilized less by mobile learning scholars outside Greater China (e.g., Khan and Gupta [5]; Goksu [6]). Zhang [10], as an example, focused on research topics and development trends of mobile learning published from 2010 to 2020 by using three software programs, namely UCINET, SPSS and CiteSpace. The results showed a steady rise in the number of relevant research papers as well as several highly cited and influential publications. The uncovered research themes included technical support, learning design, learning mode and practice. In addition to research published in Chinese journals conducted by Chinese scholars, Xu et al. [11] carried out an analysis of 2392 papers in the field of mobile learning retrieved from the Web of Science database from 1997 to 2017. That study showed mobile learning research has received extensive attention from researchers in various research fields around the world, involving three research hotspots, namely the impact of information technology development on mobile learning, the design of mobile learning systems, and context awareness for mobile learning. This study also brought to attention three relevant research frontiers: the application of emerging technologies, the smartphone-based model, and the effectiveness on students' learning.

While these studies were insightful, CiteSpace software has seldom been used by researchers outside Greater China to explore the field of mobile learning. A broad literature search uncovered only two researchers outside Greater China using this software. Khodabandelou et al. [12] conducted a comprehensive analysis of mobile learning in the domain of English learning in the 21st century and found research on English mobile learning is growing rapidly and steadily, especially studies on various device-based technologies and applications. Rawat and Sood [13] performed knowledge mapping of computer applications in education that found mobile learning has received increasing attention in applied information and communication technology in higher education, especially in engineering education. As exemplified by these two studies, CiteSpace software can detect and visualise trends/patterns in published literature [14].

The existing mobile learning bibliometric reviews have the following research limitations: (1) some of the latest reviews on mobile learning are limited to a single subject (i.e., English); (2) the data sources are extensive but may not be able to summarise the research published in competitive outlets; and (3) the time range of the literature analysed was limited, which cannot fully reflect the overall trend of the research hotspots in this field. Moreover, online learning during the COVID-19 pandemic made mobile learning a common practice, potentially leading to new developments. This study aimed to provide a detailed exploration of the past two decades of publications focusing on mobile learning appearing in the exclusive and competitive SSCI database. The study also aimed to summarise the most influential countries/regions, researchers, and publications. Having

access to this information allows for tracing of the origin of this field and to assist scholars in understanding its evolution and future trajectory.

The research questions that guided this study are:

(1) What are the mobile teaching and learning publishing trends?
(2) Who are the prolific authors in the field of mobile teaching and learning, and how strong are the researchers' collaborations?
(3) Which institutions have led to the development of mobile teaching and learning research and which institutions have had the most extensive collaborations?
(4) Which countries/regions have led to the development of mobile teaching and learning research and which countries/regions have had the most extensive collaborations?
(5) What are the mobile teaching and learning research hotspots and what future trends can be predicted?

2. Methodology

2.1. Data Source

At the beginning of 2022, SSCI-indexed journals containing the following keywords were extracted from the 2021 Journal Citation Report: "EDUCATION & EDUCATIONAL RESEARCH", "LEARN*", "TECH*", "COMPUT*", "Internet", "Distance", "TEACH*", "INSTRUCT*". From a total of 264 journal titles, removal of redundant journal titles resulted in 21 journals.

Title searches were conducted in the Web of Science Core Collection Database for each of these 21 targeted journals (TS = "mobile learning" OR "m-learning" OR "mlearning"). These searches resulted in 528 articles after the application of two inclusion criteria (see Table 1). The publications were: (1) highly relevant to mobile learning; and (2) were articles (e.g., not a book review). The full texts and complete bibliographic records for the 528 articles were retrieved.

Table 1. Article number retrieved from targeted journals.

Journals	*n*
Computers & Education	98
Educational Technology & Society	72
Education and Information Technologies	64
British Journal of Educational Technology	51
Journal of Computer-Assisted Learning	44
International Review of Research in Open and Distributed Learning	38
Educational Technology Research and Development	26
Australasian Journal of Educational Technology	26
Journal of Educational Computing Research	26
IEEE Transactions on Learning Technologies	25
Technology, Pedagogy and Education	11
Journal of Science Education and Technology	8
Distance Education	8
International Journal of Educational Technology in Higher Education	7
Journal of Computing in Higher Education	7
Learning Media and Technology	6
Internet and Higher Education	5
Research in Science & Technological Education	3
Journal of Research on Technology in Education	2
International Journal of Computer-Supported Collaborative Learning	1
International Journal of Technology and Design Education	0
Total	528

Note. *n* = article number.

2.2. Method

CiteSpace and VOSviewer are the visualisation tools that were used to conduct the bibliometric analysis. Although they share similarities, VOSviewer builds and visualises

the network based on cocitation. In contrast, CiteSpace, based on a cocitation network, offers clustering analysis, social network analysis, multidimensional scaling and other analytical methods. CiteSpace allows researchers to explore and analyze the evolution and trends of a targeted research frontier [15,16]. Therefore, this study combined these tools to gain a more comprehensive picture of the current state of mobile learning literature.

3. Results

The results are given in five parts in response to the research questions. First, descriptive bibliometric analysis via WOS reports on mobile learning research (e.g., time trends) was performed. Second, WOS and VOSviewer co-authorship was reported to identify high-yield mobile learning researchers' and their collaboration networks. The third and fourth parts further explained research hotspots and trend summaries on the knowledge mappings containing keywords and cited literature.

3.1. What Are the Mobile Teaching and Learning Publishing Trends?

An important indicator for measuring the development of a particular field is the change in the number of publications [17]. In general, the published mobile learning articles can be divided into three periods: (1) the quiet period (2003–2007), (2) the rapid rise period (2007–2010), and (3) the fluctuation period (2010–2021). Two important time points are also notable: 2006 and 2020 (see Figure 1). The number of publications in 2020 was the highest (n = 72) within the two decades and after the emergence of mobile learning research in 2003 the lowest number of publications was in 2006 (n = 0).

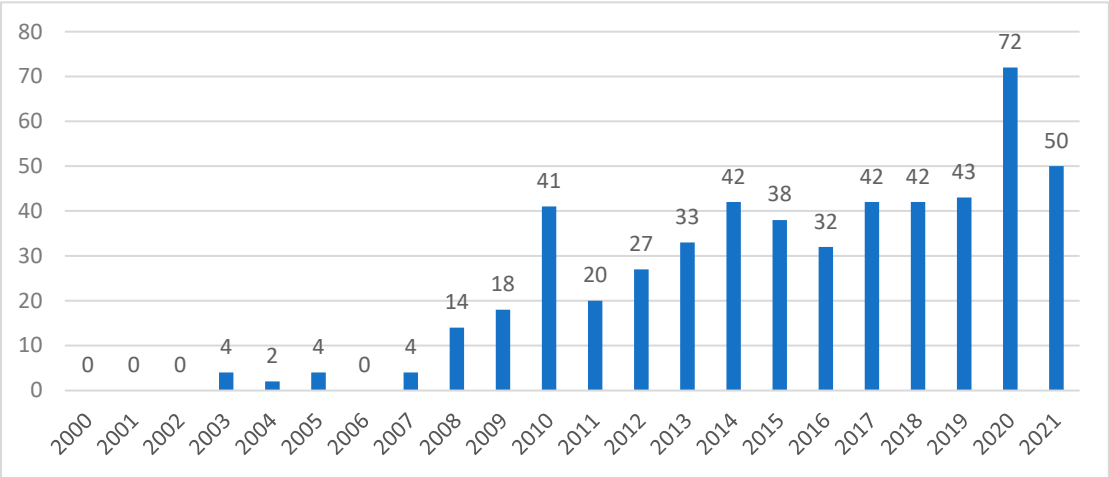

Figure 1. Number of articles by year.

3.2. Who Are the Prolific Authors in the Field of Mobile Teaching and Learning, and How Strong Are the Researchers' Collaborations?

Prolific authors are determined by their scholarly contributors calculated as the number of papers they have published in a particular research area [18]. The CiteSpace mapping analysis of prolific authors in the field of mobile learning is shown in Figure 2.

Table 2 reports the highest yielding researcher in the mobile learning field as Gwo-Jen Hwang. His publication number is nearly double that of the scholars ranked 2 and 3 and nearly thrice of scholars ranked 4 and 5. Gwo-Jen Hwang has been reported as tending to investigate mobile devices as teaching/learning tools in practice [4,19–21]. Gwo-Jen Hwang has stronger collaborations with a larger number of researchers than the other high-yield authors. This is likely due to the large number of publications he has produced—the more publications, the more collaboration.

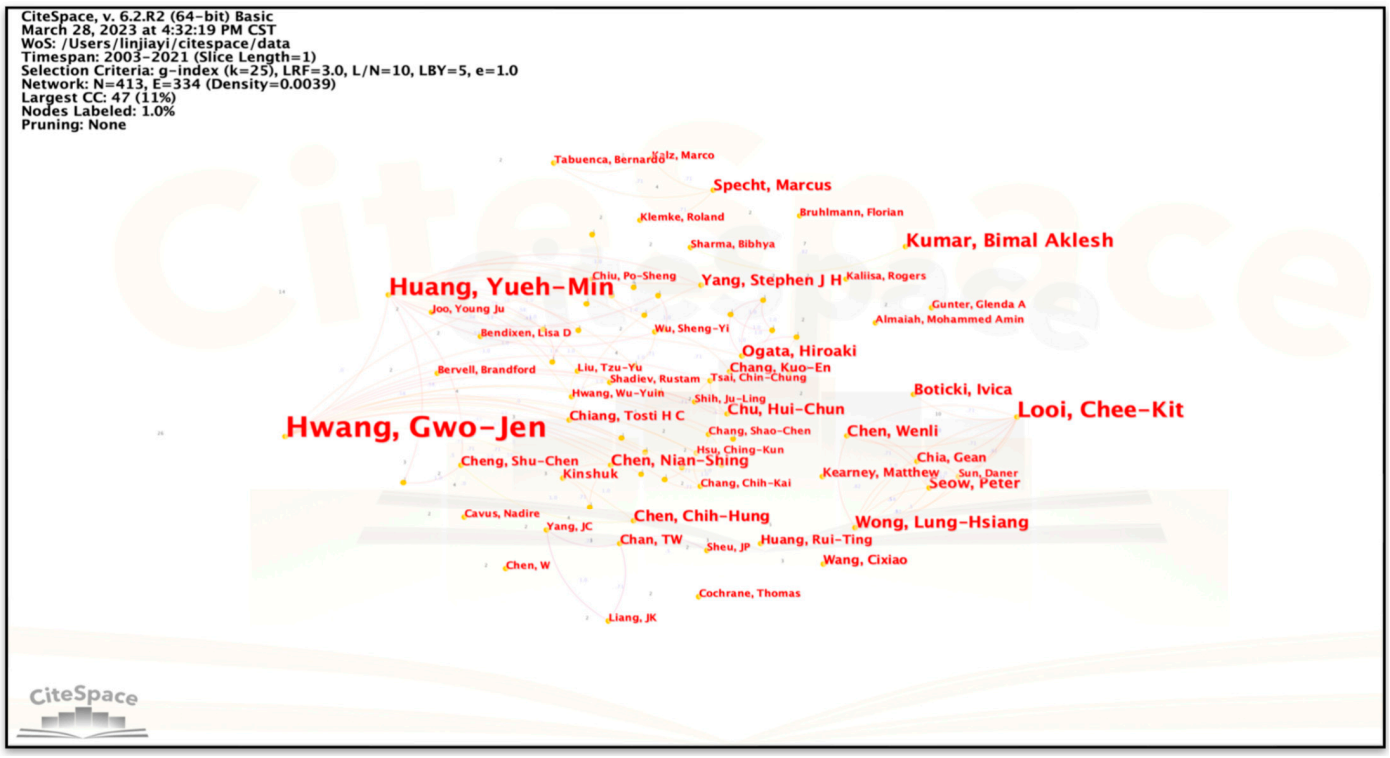

Figure 2. The knowledge mapping of most prolific authors in the field of mobile teaching and learning.

Table 2. Most prolific researchers in the field of mobile learning.

Rank	Researcher	*n*	% of 528 Articles
1	Gwo-Jen Hwang	29	5.49%
2	Yueh-Min Huang	16	3.03%
3	Chee-Kit Looi	15	2.84%
4	Wu-Yuin Huang	10	1.89%
5	Lung-Hsiang Wong	10	1.89%

Table 2 reports the second highest yielding researcher in the mobile learning field is Yueh-Min Huang. Yueh-Min Huang's research interests are in the effective use of mobile systems in various educational fields, such as language learning, science curricula, and nursing; his research also involves the design of a cognitive diffusion model in a mobile learning environment [4,22,23].

The remaining three researchers have focused their research on teachers and students in primary school and elementary school [24–26].

3.3. Which Institutions Have Led to the Development of Mobile Teaching and Learning Research and Which Institutions Have Had the Most Extensive Collaborations?

Institutions serve as major scientific research forces in one country or region. This section reports the number of publications produced by each institution to identify the regional distribution of mobile learning research and to explore the partnerships between each university (see Table 3). National Taiwan University of Science Technology and National Central University are both high-yield institutions. Universities in Taiwan took the top four spots. The other top-yield institution is in Singapore. However, Singapore was not found to be a prolific country or region for mobile learning (see Table 4). While the yield of publications per university in Singapore is high, the overall yield of publications cannot amass those of Taiwan, USA, and Mainland China. This is likely due to the large number of universities in these countries/regions.

Table 3. Most prolific institutions in the field of mobile teaching and learning.

Rank	Institution	*n*	%
1	National Taiwan University of Science and Technology	32	6.06%
2	National Central University	30	5.68%
3	National Cheng Kung University	21	3.98%
4	National Taiwan Normal University	20	3.79%
5	Nanyang Technological University	18	3.41%

Table 4. Most prolific countries/regions in the field of mobile teaching and learning.

No	Country/Region	*n*	Percent
1	Taiwan	129	24.43%
2	USA	82	15.53%
3	Mainland China	58	10.99%
4	England	37	7.01%
5	Australia	34	6.44%

Figure 3 shows the co-authorship network of the top 18 prolific institutions in the field of mobile learning. National Taiwan University of Science and Technology occupied the first place due to it possessing the most robust collaboration network (link strengths = 26). The collaboration strengths of National Central University, National Taiwan Normal University, National University of Tainan, and National Cheng Kung University are all approximately 16. Figure 4 shows that the co-authorship collaboration network of co-authors contains nine items and three clusters. The main contributors are three researchers, Gwo-Jen Hwang, Yueh-Min Huang, and Stephen J.H. Yang.

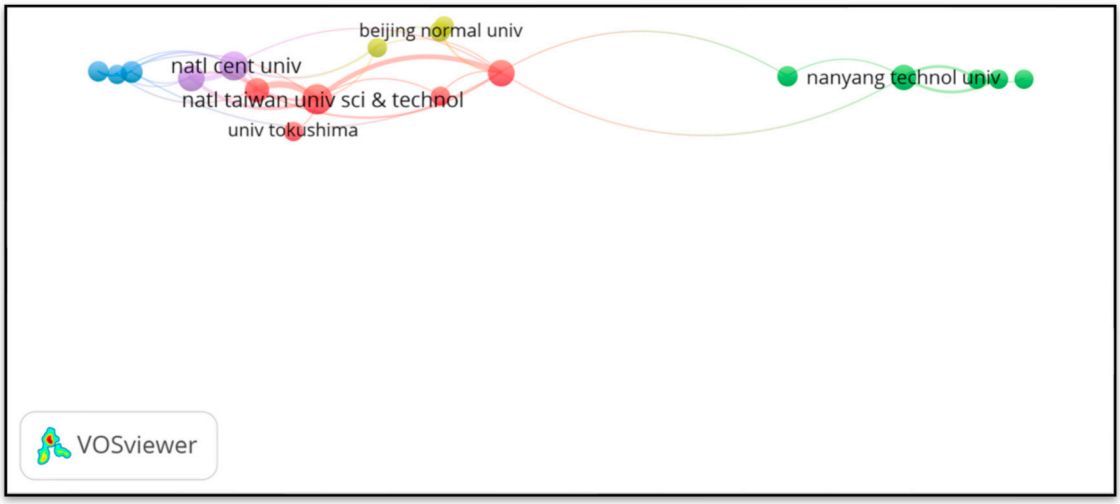

Figure 3. The knowledge mapping of co-authorship collaboration network among institutions.

3.4. Which Countries/Regions Have Led to Development of Mobile Teaching and Learning Research and Which Countries/Regions Have Had the Most Extensive Collaborations?

Table 4 lists the most prolific countries/regions in the field of mobile learning. Taiwan is at the top, possessing the highest number of published papers (*n* = 129, 24.43%). The USA has also made an outstanding contribution to mobile learning, ranking them second. Likewise, Mainland China has also made its mark with a third-place ranking.

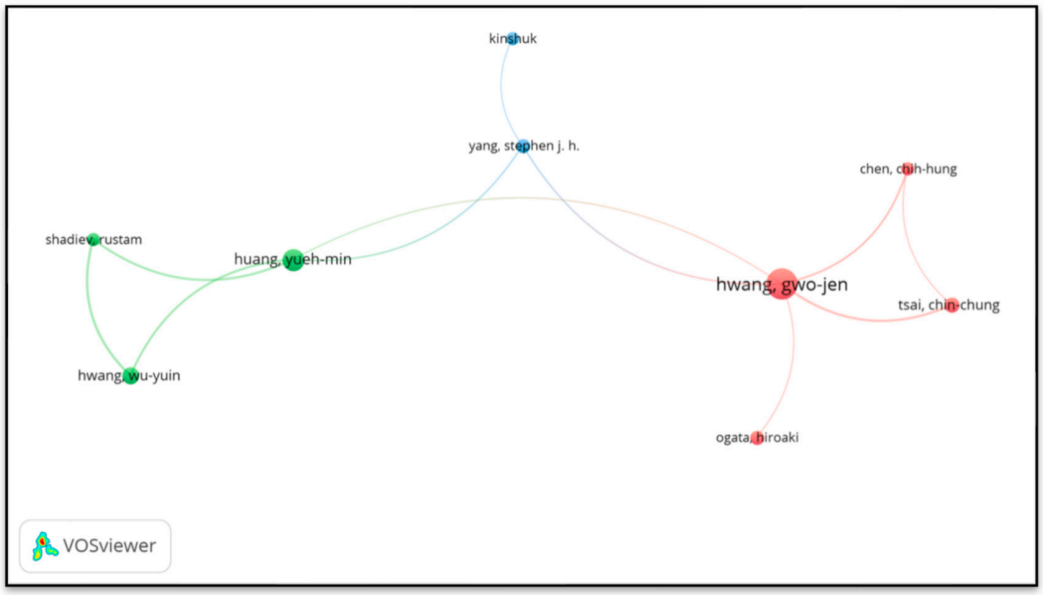

Figure 4. The knowledge mapping of co-authorship collaboration network among mobile teaching and learning scholars.

The VOSviewer software analysis clearly demonstrates the co-authorship of the mobile learning researchers. The link connecting two circles represents co-authorship, while the same circle colour represents one cluster. The size of the circle implies the percentage of total publications analysed. Figure 5 shows that the top 27 countries/regions can be clustered into 6 groups. USA authors ($n_{publications}$ = 82; link strength = 41) possess a strong collaborative relationship with researchers from 13 other countries/regions. Scholars from Taiwan also possess a strong collaborative relationship with researchers from 27 other countries/regions through many co-authored publications ($n_{publications}$ = 129; link strength = 35).

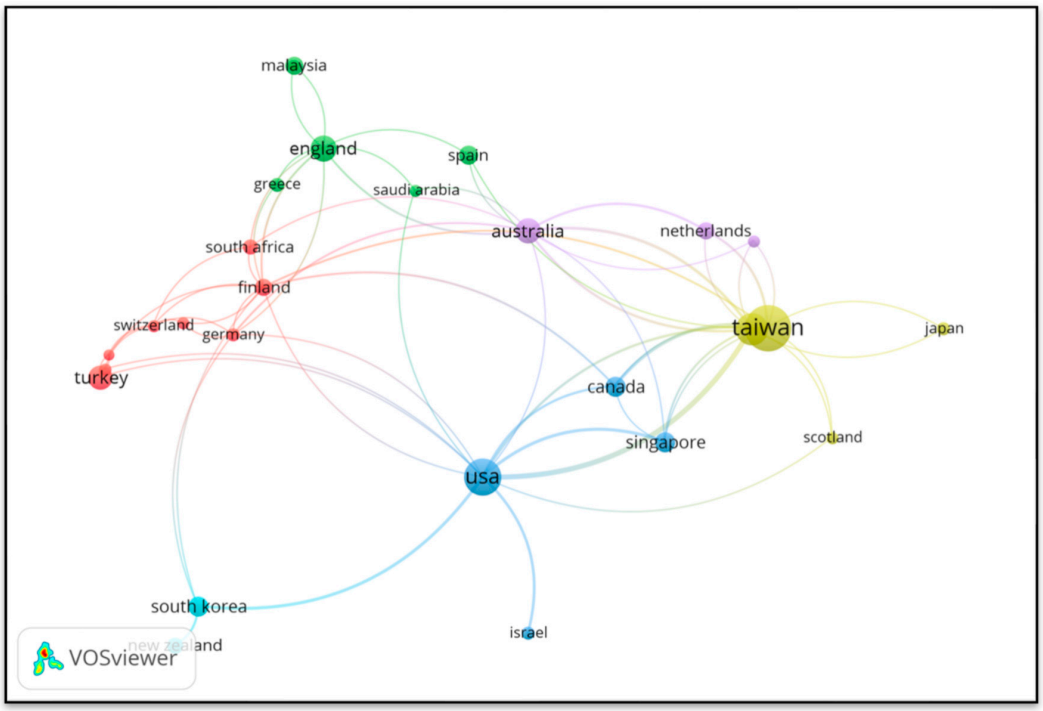

Figure 5. Co-authorship among most prolific countries/regions in the field of mobile teaching and learning.

3.5. What Are the Mobile Teaching and Learning Research Hotspots and What Future Trends Can Be Predicted?

3.5.1. Keyword Co-Occurrence Analysis

Examining high-frequency and high-centrality keywords can give researchers an idea about the developmental trends and research hotspots in the mobile learning field. Centrality refers to the degree of importance of a node (e.g., a keyword, a publication, or an author) and year refers to the year in which the keyword first appeared. After extraction of the keywords from the publications, the mapping of their co-occurrence was computed and is illustrated in Figure 6. Table 5 provides the high-frequency keywords (i.e., those occurring 15 times or more). Manual analysis of all the keywords allowed for them to be grouped into three main themes: (1) the design of mobile learning system, (2) the acceptance of technology, and (3) students' performance after using a unique teaching strategy.

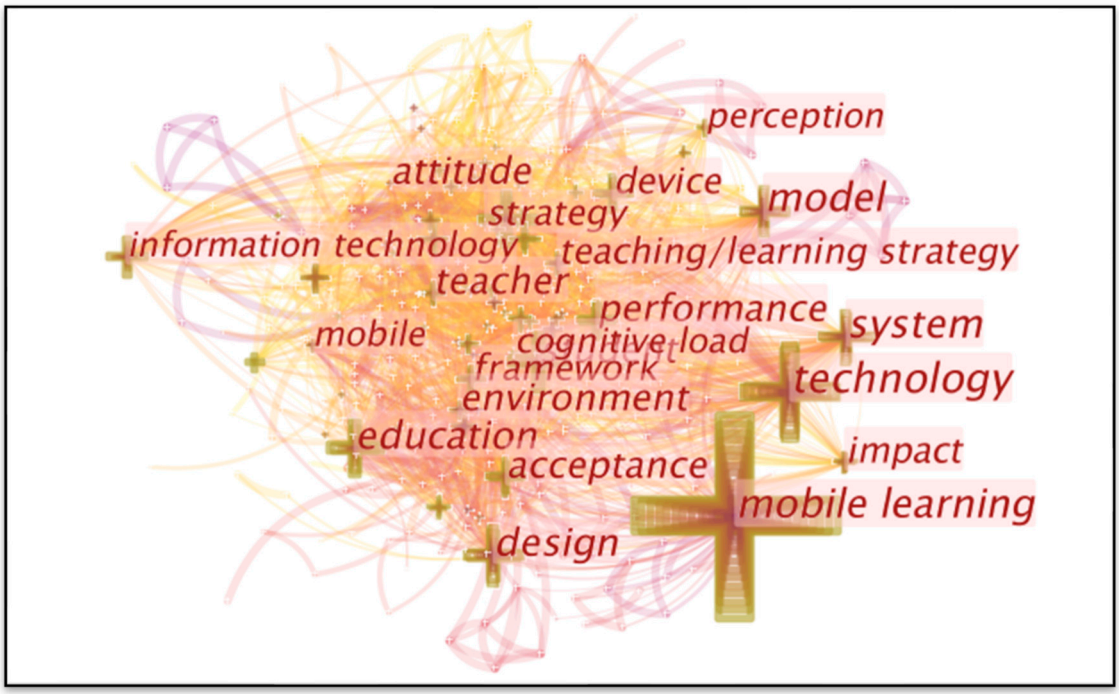

Figure 6. The knowledge mapping of the keywords co-occurrence.

3.5.2. Keyword Clusters

The VOSviewer software timeline view of the keyword network showed 411 keyword nodes and 2303 links between them. We used the keywords and log-likelihood ratio (LLR) weighing algorithm to identify 11 keyword clusters. Each cluster was labelled with an appropriate research cluster theme name based on the most frequently occurring keywords found within it. CiteSpace software offers two indicators: modularity (Q) and silhouette (S) [27]. Modularity refers to a measure of how well the nodes in the network are organised into cluster communities based on their co-occurrence pattern while the silhouette value is a measure of the consistency and the quality of the cluster. The silhouette values ranged from −1 to 1, with higher values indicating better clustering. This study shows a precise clustering boundary and clustering scale. Q is equal to 0.3836 (>0.3), and S is equal to 0.7392 (>0.5). Table 6 provides relevant information on the keyword cluster analysis.

Table 5. High-frequency keywords.

Count	Centrality	Year	Keywords
300	0.30	2005	Mobile learning
89	0.20	2007	Technology
64	0.06	2009	Student
53	0.11	2008	Education
51	0.09	2008	Design
51	0.14	2010	System
46	0.03	2010	Higher education
36	0.06	2010	Performance
35	0.06	2010	Acceptance
35	0.12	2010	Model
29	0.05	2011	Device
28	0.03	2009	Adoption
26	0.02	2012	Information technology
26	0.02	2013	Science
25	0.07	2010	Framework
25	0.05	2013	Impact
23	0.07	2007	Teacher
22	0.02	2014	Technology acceptance model
20	0.08	2007	Attitude
20	0.06	2008	Environment
20	0.03	2012	User acceptance
19	0.02	2015	Motivation
18	0.05	2011	Achievement
17	0.05	2009	Augmented reality
17	0.05	2015	Perception
17	0.05	2011	Strategy
17	0.03	2011	Teaching/learning strategy
16	0.04	2008	Mobile
15	0.02	2007	Ubiquitous learning

The keyword cluster themes can roughly be grouped into three large groups. Arcs model and mobile learning possess the earliest mean citation year. IT use, computer use in education, collaborative learning process, teaching/learning strategies, mobile phone, and education all have mean citation years that fall somewhere in the middle of our years of interest. More recent themes include technology acceptance model, games, and student achievement.

Cluster 1

With the advancement of wireless internet and 3G/4G/5G, contemporary teaching and learning have been transformed by the development of revolutionary technologies. Mobile learning can take place in any learning environment or space regardless of the type of mobile technology, learners, and learning methods [1]. For example, Chen and Chung [28] reported on a personalised mobile English vocabulary learning system based on item response theory and the learning memory cycle. As one of the most significant educational outcomes produced by the information technology industry, mobile learning has significantly changed when and where students can learn; it has created a situation where learners seamlessly switch between formal and informal contexts and between individual and social learning [29].

Several studies have indicated that mobile devices can improve students' achievements and enhance motivation [30]. As an example, Shih et al. [31] found a positive relationship between student learning and mobile device usage. Mobile devices enhance learning motivation through challenge, curiosity, control, recognition, competition, and cooperation [32]. Likewise, the use of radio frequency identification technology has been shown to encourage certain learning behaviours [33]. The use of mobile devices can also encourage cooperation between learners [34]. Similarly, Gikas and Grant [35] found mobile

computing devices and social media provided opportunities for student interaction and collaboration among peers. It allowed students to post content and communicate online.

Table 6. Keyword cluster analysis results.

Research Cluster Theme	Cluster Size	Silhouette Value	Mean Citation Year	Keywords (Top 10)
teaching/learning strategies	75	0.621	2013	Design, System, Performance, Teaching/Learning strategy, Interactive learning Environment, Challenge, Cognitive load, English, Elementary education, applications in the subject area
mobile learning	68	0.767	2009	Mobile learning, Education, Environment, Mobile, Ubiquitous learning, Computer, Case study, Wireless, Personal digital assistant, Informal learning
technology acceptance model	57	0.776	2015	Student, Higher education, Model, Acceptance, Adoption, Information technology, Technology acceptance model, User acceptance, Attitude, Perception
games	43	0.722	2015	Impact, Motivation, Achievement, Augmented reality, Collaborative learning, Game, Engagement, Online, Science Education, Feedback.
mobile phone	34	0.849	2013	Knowledge, Context, Pedagogical issue, Belief, Distance education, ICT, Media, Professional development, Cloud computing, Mobile phone
education	31	0.554	2013	Technology, Teacher, Experience, Self-efficacy, Antecedent, Language, Facebook, Authentic context
student achievement	29	0.744	2016	The device, Science, Mobile device, Instruction, Trend, Perspective, Adaptive learning, Smartphone, Integration
computer use in education	20	0.864	2011	Frame, Attention, Animation, Concept map, Computer uses in education, Construction, Museum learning, Working memory, Interactive learning environment, 2D barcode, Phone.
IT-use	10	0.928	2010	Classroom, School, TPACK, Video games, Schoolchildren, Cardiopulmonary resuscitation, Ubiquitous computing, Project-based science, Bystander CPR, Project-based learning
arcs model	7	0.988	2008	Learning object, Arcs model, motivational object, Handheld device, Computer-assisted instruction, Pedagogical agent, Message
collaborative learning process	7	0.935	2011	Communication, Team, Environmental awareness, Elementary, Collaborative learning outcome, Cognition, Collaborative learning process

Cluster 2

Researchers have highlighted several teaching strategies, models, and constructs related to mobile learning that have the potential of promoting students' learning effectiveness. These include a positive attitude [36], interactive concept map-oriented teaching [20], wearable technologies [37], online courses [38], information delivery medium [39], formative assessment-based mobile learning [40], enquiry-based learning [41], personalized mobile learning [42], MOOC platforms [43], and evidence-based approaches [44], among others.

Cluster 3

Learning and teaching model design is receiving increasing attention from researchers. Some examples include Al-Hmouz et al. [45] that designed an adaptive neuro-fuzzy inferencing system aimed at delivering adapted learning content to mobile learners and Shin and Kang [46] that extended the technology acceptance model to the investigation of students' acceptance of mobile learning in an online environment. Specifically, Shin and Kang's [46] study provided a better understanding of the mobile learning environment's influence on learning achievement. It should be noted that mobile learning is not without any drawbacks. Churchill and Hedberg [47] underscored that most mobile devices use small screens that could present several pedagogical and technological limitations.

Without location limitations, learning can occur anywhere, even in the outdoors [48]. Specifically, Land and Zimmerman [48] found utilising mobile devices can support informal science education outside the classroom by enhancing families' and children's learning experiences outdoors. Another example is Jong et al. [41], which developed Gamified Authentic Mobile Enquiry in Society (GAMES) to support students in conducting authentic outdoor inquiry-based learning. In a similar vein, Hung et al.'s [49] study reports on the development of a scaffolding framework in a mobile learning environment to support inquiry-based teaching. The framework has three layers: guided observation with multiple-choice items, independent observation with short response items, and extended observation with learning diary development. Based on the scaffolding provided by the mobile learning environment, students improved their competence in contextualisation, internalisation of ecological knowledge, and reflective thinking.

3.5.3. Keyword Burst Detection

Figure 7 displays the top 13 most frequent keywords in the analyzed papers. As no publications were produced between 2000 and 2002, the analysis was performed on years 2003 to 2021. The keywords appearing in the most recent years include: student, higher education, adoption, game, achievement, and intention.

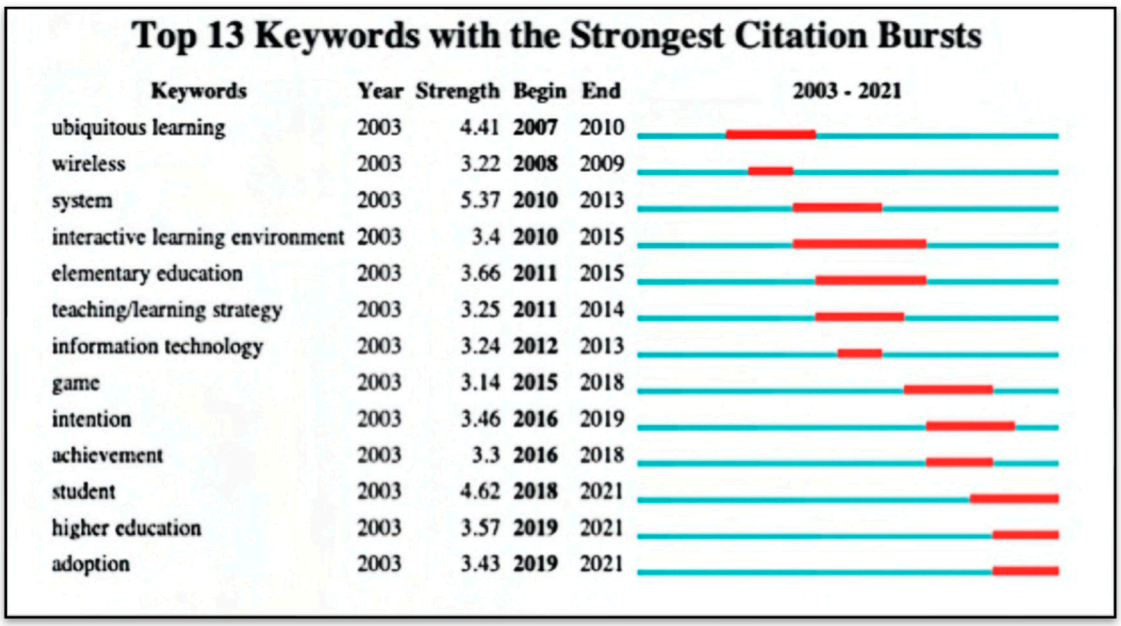

Figure 7. Top 13 keywords with the most robust citation bursts.

3.5.4. Co-Cited Literature Analysis

The citations of the five most frequently cited articles were extracted and are visualized in Figure 8. Their relevant information is provided in Table 7.

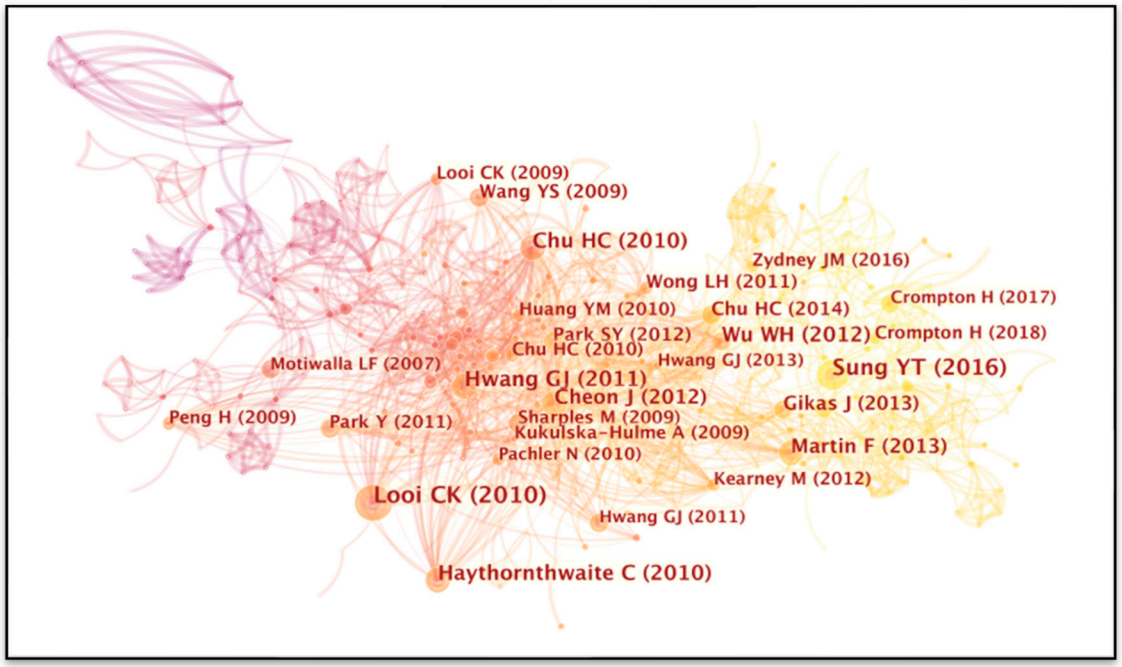

Figure 8. Co-cited literature analysis.

The top five high-frequency co-cited publications focused on the effectiveness of mobile devices. Looi [29] discussed mobile technology as a research agenda for sustainable seamless learning. Hwang and Chang [40] explained a formative assessment-based mobile learning model. Chu et al. [50] introduced *Mindtools*, an application to situate students in an environment that combines real-world and digital-world learning resources. Sung et al. [51] conducted a meta-analysis of 110 experimental and quasi experimental studies that found the application of mobile devices had a moderate effect on learning. Wu et al. [4] reported on the following trends from mobile learning studies: (1) their effectiveness and design; (2) how mobile devices have changed; and (3) how mobile learning is applied in professions and applied sciences.

Table 7. Articles with high-frequency co-citations.

Rank	Co-Citations	Centrality	Authors	Year	Title
1	27	0.11	Looi [29]	2010	Leveraging mobile technology for sustainable seamless learning: a research agenda
2	24	0.07	Sung et al. [51]	2016	The effects of integrating mobile devices with teaching and learning on students' learning performance: A Meta-Analysis and Research Synthesis
3	22	0.11	Hwang and Chang [40]	2011	A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students
4	20	0.07	Wu et al. [52]	2012	Review of trends from mobile learning studies: A meta-analysis
5	18	0.13	Chu et al. [50]	2010	A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning

4. Conclusions

The aim of this study was to uncover: (1) the mobile teaching and learning publishing trends; (2) the prolific authors publishing and collaborating in publications on mobile

teaching and learning; (3) the prolific institutions and their collaborators publishing on mobile teaching and learning; (4) the countries/regions producing and collaborating on mobile teaching and learning research; and (5) the predicted mobile learning and teaching research hotspots and trends. Within the time frame examined, a noticeable increase in mobile teaching and learning articles started in 2008 and peaked in 2021. While research on mobile learning and teaching was found to have been produced throughout the world, the lion's share is from Taiwan. Notably, Gwo-Jen Hwang, along with other Taiwanese researchers, has paid substantial attention to this field. There is a noticeable collaboration between the authors that are producing most of the research in this field, with more research production resulting in more collaboration. This can be shown for not only individual authors but also countries/regions and for institutions. Keyword co-occurrence analysis and cluster analysis found 11 relevant clusters that could be narrowed down into three mobile learning and teaching hot topics. The most frequent keywords include: student, higher education, adoption, game, achievement, and intention. The most frequently cited publications dealt with the effectiveness of mobile devices for learning.

These findings provide scholars with an accessible summary of: (1) the current trends in mobile learning; (2) the active researchers in this field; and (3) the outlets that are most relevant for research produced on this topic. These findings have direct implications for the education and private sectors because mobile devices are not widely adopted in classroom settings and are often considered a learning tool more suited for out-of-class assignments or practice. Summarising the development of mobile learning, especially the effectiveness of mobile devices, allows for an understanding of the advantages and disadvantages of mobile devices for learning and instruction. Once the integration of mobile technology is actively initiated in the classroom by information technology educators, those in the technology industry should aim to develop mobile devices and relevant educational applications/software that can be utilised not only within the confines of the classroom but also to bridge in-class and out-of-class learning.

The findings of this study should be considered in connection with its limitations. First, the results are limited in that search terms for only SSCI-indexed journals were covered. If non-SSCI-indexed journals had also been included or other databases, the results would have differed. Second, the time span of analysis ended in 2021, which some might argue was still in the middle of the COVID-19 pandemic. It would be worthwhile for future research to compare these results before the pandemic to those after the pandemic.

Author Contributions: Conceptualization, C.W.F.; Data curation, J.L.; Formal analysis, J.L.; Funding acquisition, C.W.F.; Investigation, J.L.; Methodology, C.W.F.; Project administration, C.W.F.; Resources, C.W.F.; Software, J.L.; Supervision, C.W.F. and B.L.R.; Validation, J.L.; Writing—review and editing, C.W.F. and B.L.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The authors of this paper confirm that the present study, entitled "A Bibliometric Analysis of Trending Mobile Teaching and Learning Research from the Social Sciences", is a systematic review and does not involve primary data collection, experimentation, or direct human subject research. As such, no human subjects, human material, or human data have been involved in the study, and therefore, the study is exempt from requiring Institutional Review Board (IRB) approval.

Informed Consent Statement: This systematic review adheres to established guidelines and methodologies. This study aimed to synthesis and analyses existing literature and published data to address the research questions outlined in the paper. The sources of information utilized in this study consist solely of publicly available, previously published research articles, reports, and other relevant documents. No personal, sensitive, or confidential information has been accessed or used during this study.

Data Availability Statement: In accordance with the data availability guidelines set forth by MDPI journals, we confirm that all the data used in this study can be found within the cited references. The full citation details of the included studies are provided in the reference list of this paper. Any additional information, files, or analysis tools used in this study can be made available upon reasonable request to the corresponding author at andyfan@um.edu.mo.

Conflicts of Interest: The authors declare no conflict of interest.

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A Bibliometric Analysis of Augmented Reality in Language Learning

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Abstract: As an emerging technology, augmented reality has been increasingly entering the educational field. Previous studies of AR are strongly associated with scientific education but lack the mention of language learning. This study aimed to analyze the use of AR tools in language learning contexts using the bibliometric tools VOSviewer and CitNetExplorer using both qualitative and quantitative research methods. This study analyzed the top ten authors, sources, countries, and organizations using VOSviewer and established citation networks using CitNetExplorer. The study found that both teachers and students showed a positive attitude toward AR tools in language learning. Games, 3D images, and videos are the main ways to instantiate virtual elements into the real world, and the most widely used tool in AR-assisted learning was HP Reveal. Moreover, the study also found that AR tools could enhance language learning by presenting an immersive learning context, increasing motivation, providing interaction, and reducing anxiety. Future research will contribute to how AR tools influence students' learning performance and teachers' teaching activities.

Keywords: bibliometric analysis; augmented reality; VOSviewer; CitNetExplorer; language learning

Citation: Min, W.; Yu, Z. A Bibliometric Analysis of Augmented Reality in Language Learning. *Sustainability* **2023**, *15*, 7235. https://doi.org/10.3390/su15097235

Academic Editors: Rustam Shadiev, Barry Lee Reynolds and Rui Li

Received: 20 March 2023
Revised: 7 April 2023
Accepted: 13 April 2023
Published: 26 April 2023

1. Introduction

With new educational technologies emerging, more opportunities are offered for computer-enhanced language learning approaches [1]. Research on AR in language learning began in 2008 and continues to progress. As a newly introduced technology, AR plays an important role for students in language learning. According to [2], one of the barriers of learning English in non-English speaking countries is the lack of real contexts outside of the classroom. For this problem, AR can instantiate virtual elements into the real world and create a real English-learning context for learners. Furthermore, statistical analyses show that teaching with AR technology can help students improve their motivation in language learning, which can directly influence their performance [3]. Aside from the benefits for students, AR can also offer educators new opportunities to engage learners in innovative ways [4]. Thus, it is important to develop a framework for conceptualizing and promoting the use of AR in language learning.

As an emerging technology, augmented reality is increasingly entering the field of education. However, the language skills currently used in AR technology require relatively lower cognitive engagement, such as pronunciation, meaning comprehension, and word recognition. There is a lack of more complex language skills used in the AR applications, such as reading and writing [5]. Additionally, according to the search results from Web of Science, there are much more meta-analyses and systematic reviews than bibliometric studies (shown in Table 1). Table 2 shows that the research conducted by [6] focused on the performance and production of AR in the field of education, with 777 publications involved. Another research conducted by [7] aimed to find out the importance of English mobile learning. A total of 5434 publications were analyzed. However, these research studies only introduced the importance and production of AR tools without exploring the actual use

of AR in language learning. Therefore, a study combining a bibliometric analysis and the application of AR with a sufficient number of included publications is needed.

Table 1. The number of publications of different review studies on AR tools in language learning.

Study Type	Time Period	Number of Publications
Meta-analysis	2013–2022	30
Systematic review	2016–2022	48
Bibliometric analysis	2020–2022	2

Table 2. The comparison between previous bibliometric studies on AR-enhanced language learning and this study.

Authors/Year	Highlights	Research Topics	Number of the Publications Included	Bibliometric Tools
[6]	The performance and production of AR in the field of education	Top 5 knowledge fields; document type; institutions; authors; sources; countries and most cited articles on AR in the field of education; and the way to teach AR effectively.	777	Science Mapping Analysis Tool (SciMAT)
[7]	The importance of English mobile learning	Research direction and type; years; countries; productive institutions, top authors, and co-occurrence; co-authorship, citation, and co-citation; top 10 cited sources; and the top 20 keywords through VOSviewer.	5343	VOSviewer and CiteSpace
This study	The use of AR tools in language learning	Annual trend of publications; top 10 authors, sources, organizations, and countries; users' attitudes; ways to integrate with language teaching and learning; and the effects of AR.	1275	VOSviewer and CiteSpace

The bibliometric analysis was performed using the application of quantitative techniques for domain-specific bibliometric data. Software such as VOSviewer and CitNetExplorer are essential for bibliometric analyses. These programs provide bibliometric graphs that show co-authorship, citations, and bibliographic links between papers by analyzing data downloaded from digital databases, which can be visualized to quickly focus on hot topics in a particular field. This method has many advantages in terms of efficiency and accuracy over traditional quantitative methods. It allows for a comprehensive and objective identification of research gaps and hot issues in a given field while reducing the cognitive load on the reader.

The analysis of this study combines quantitative and qualitative research methods [8]. At the beginning of this study, the use of AR in e-learning was analyzed through VOSviewer, including the trend of publications and citations, as well as the top ten authors, sources, organizations, and countries. Secondly, citation networks were created by using clustering techniques; the two longest citation paths were drilled down using CitNetExplorer. Finally, according to the two longest citation paths, conducted a bibliometric analysis to examine users' attitudes toward AR, the effects of AR use, and how language learning is integrated with AR.

The current study is composed of six parts. Section 1 is the introduction of the study, which includes the background information, significance of the study, two bibliometric tools of the study, and overall structure of the study. Section 2 provides a general statement about the literature review, which includes the previous studies of AR, AR in language learning, and users' attitudes toward the technology; the research purpose and questions are also proposed in this chapter. Section 3 contains the research methodology; it consists of the scope of the study, application of the two bibliometric tools, and procedure of data collection and data analysis. Section 4 shows the results of the bibliometric analysis, which is followed by the discussion of the research results in Section 5. Section 6 provides the

conclusion of the study and includes three parts: major findings, limitations of this study, and implications for future research.

2. Literature Review

2.1. Previous Studies of AR

The studies of AR can originate back to the 1950s. The term AR was introduced by Tom Caudell in 1990. Subsequently, Ref [9] found the reality–virtuality (RV) continuum, which combines reality and virtuality. In the RV continuum, the real environment is situated on the left side, which solely includes the environment consisting of real objects. The virtual environment is on the right side of the RV continuum, which solely consists of virtual objects. In this framework, mixed reality (MR) is defined as anywhere on the RV continuum between these two extreme environments. Within the class of MR, augmented reality is analogous but antithetic to augmented virtuality. Therefore, under the background of the RV continuum, it would be more clear to understand the definition of AR such that it is "augmenting natural feedback to the operator with simulated cues" [9]. In 1997, Azuma conducted the first study on the use of AR. In recent years, AR has developed at a high speed with the emergence of mobile applications [10]. AR produces the best of the natural environment and available virtual information. The elements of reality and virtuality in AR offer users a new world supported by virtual information.

AR is an enhanced, interactive version of a real-world environment, which is achieved by using digital elements; this means that AR can help users see virtual objects as composited within the real environment [11]. In fact, AR technology is not limited to a specific type, nor is it restricted to vision; it can also be used to enhance smelling, touching, and hearing [12]. Nowadays, AR has been applied in many fields in modern society, including advertising and marketing [13], architecture [14], and entertainment [15]. It has also been adopted in education [16,17], such as in the sciences, in math, and in literacy [18,19]. Augmented reality is applied by learners at different stages of schooling, ranging from primary school to college students [20]. Although numerous research studies have been conducted to investigate the importance and effect of AR, there is a lack of a bibliometric analysis of the findings with respect to language learning. With the development of research in this field, researchers are working hard to discover the issues and trends across the entire field. Therefore, it is urgent and necessary to develop a bibliometric study to provide directions for future study.

2.2. AR in Language Learning

AR is a real-time representation using computer-generated images, sounds, or videos that allows users to interact with the real world in an augmented way [10]. As an assistant tool, the application of this technology is very important in language teaching and learning [21] because mobile applications for touch screens can offer children new opportunities for language learning [22]. However, foreign language teaching is difficult and needs effective skills to avoid boredom. AR can provide an augmented learning context, which can help children enrich their language learning experiences through the combination of virtual and real environments. Ref [23] conducted a study on collaborative modeling in augmented reality. The authors found that the use of AR tools may have a positive influence on learners' perceived efficacy and self-perception, which can directly impact learners' performance. The authors also pointed out the limitations of AR tools in that the environment within AR may depend on students' background knowledge and their familiarity with real world settings.

However, the above studies have commonly focused on the benefits and limitations of AR applications while neglecting how these technologies can help children and how the AR technologies were integrated into the teaching and learning. Based on the application of AR in previous studies, this paper will systematically explore the effect of AR on language learning and the ways to integrate AR tools with language learning.

2.3. Users' Attitude

Research has shown that users' attitudes toward educational technology has a great effect on technology adoption [24]. This is because teachers' negative attitudes affect their way of thinking and directly hinder the integration of technology in language teaching. In contrast, teachers with positive attitudes toward the use of a technology are more likely to adopt it. Ref [24] found that the same applies to learners. Students who use technology to learn can show higher levels of motivation and interest. Previous studies have found that most teachers and learners behave positively toward AR tools in the language classroom [11]; however, this previous research only included studies published before 2019. Therefore, this paper will examine users' attitudes toward AR use in language learning based on recent publications.

2.4. Research Purpose and Questions

According to the literature review, this study will analyze the AR use in language learning from a bibliometric point of view and explore the users' attitude toward AR, ways of integrating AR, and effectiveness of AR. The research questions are as follows:

RQ1: What is the year-based trend of included publications and citations?

RQ2: What are the top ten authors, sources, organizations, and countries among the studies on AR in language learning?

RQ3: What are the users' attitudes toward AR tools in language learning?

RQ4: What are the effects of AR on language learning?

RQ5: How are AR tools integrated with language learning?

3. Methods

3.1. Defining the Scope

Defining the purpose and scope in the bibliometric analysis is the first thing that needs to be done [25]. In this study, authors have retrospected the research achievements and science in this field, which means unpacking the rich research constituents and uncovering the networks between the constituents in each research. Moreover, according to [25], the scope of a bibliometric analysis needs to include 500 papers or more. Therefore, the number of analyzed publications in this study will be over 500.

3.2. Technical Tools

In this study, we attempted to bibliometrically analyze the use of AR by using VOSviewer and CitNetExplorer. We analyzed the citation networks and performed a bibliometric analysis with the help of CitNetExplorer and VOSviewer [26]. CitNetExplorer focuses on analyzing and visualizing a citation network, which can show the publication year, citation score, publication group, cluster publications based on citation relationships, and can drill down the large citation network; meanwhile, VOSviewer mainly focuses on visualizing bibliometric networks based on citation, co-citation, co-occurrence, and co-authorship. Both methods allow for a visualization of the clustering results. The assignments of publications into different clusters are linked to the relatedness of publications. In this study our clustering technique CitNetExplorer does not take the direction of a citation into account, which means that there is no distinction between publication i citing publication j and publication j citing publication i [8]. The clustering parameters in CitNetExplorer contain a resolution parameter, which is 1.00, and a minimize cluster size parameter, which is 10. Moreover, the optimization parameters include: the number of random starts, which is 1; the number of iterations, which is 10; and random seed, which is 0. Due to the defined minimum size, 94 publications were not included in the clustering. CitNetExplorer tends to cluster at the individual level, while VOSviewer mainly clusters at the global level of bibliometric analysis [27]. Both methods allow for a visualization of the clustering results.

3.3. Data Collection

Instead of key words, citation networks were used to identify the relationship between publications. Because of the difficulty of clarifying the exact meaning, keywords were not used to define relationships. Keywords can be interpreted differently in different contexts. This can lead to ambiguity in the classification of clusters, causing difficulties in the analysis of clustering decisions. Because co-citation and bibliographic coupling are the indirect estimates of relationships, they do not offer direct and precise information. Therefore, they cannot be used as criteria for determining relationships between publications [28]. CitNetExplorer clusters publications according to their relationships. To avoid technical or analytical problems, we assigned some publications in this study to unique groups [8].

The procedure of data collection was as follows. On 13 November 2022, we searched the Web of Science tool by entering "AR" OR "augmented reality" (topics) and "language learn*", "language teach*", and "education", obtaining 1318 open access results, which were used in the bibliometric analysis with the help of VOSviewer. The document types included articles (N = 1101), review articles (N = 232), early access articles (N = 43), editorial materials (N = 24), proceeding papers (N = 11), book chapters (N = 6), corrections (N = 2), letters (N = 2), book reviews (N = 1) and meetings (N = 1). A total of 1318 articles were found using the Web of Science tool. Studies were included if they (1) focused on AR and language learning, (2) provided sufficient information for the study, (3) were written in English, and (4) contained convincing results. Studies were excluded if they were (1) duplicates, (2) irrelevant, (3) not relevant to the research question, (4) written in another language, (5) not full texts, or (6) not relevant to the education sector. Based on these criteria, 1318 titles and abstracts were evaluated. Finally, 1275 articles were chosen for further bibliometric analysis using CitNetExplorer.

The timeline ranged from the inception of the online databases to the year 2022. The researchers developed the search strategies and obtained literature by searching the Web of Science tool on 13 November 2022. Web of Science includes many databases, such as the Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index-Science, Conference Proceedings Citation Index-Social Science & Humanities, Emerging Sources Citation Index, Current Chemical Reactions, and Index Chemicus. Therefore, the use of Web of Science could reduce the selection bias and improve the representativeness of the included studies [24].

To increase reliability, the publications that were included were chosen from a variety of sources and were available in different languages. The main sources included *Computers & education* (N = 221), *Educational Research Review* (N = 134), *Educational Technology & Society* (N = 89), *Education Science* (N = 68), *Interactive Learning Environments* (N = 64), *Computers in Human Behavior* (N = 50), *Personal and Ubiquitous Computing* (N = 50), *International Journal of Environmental Research and Public Health* (N = 31), *Eurasia Journal of Mathematics, Science and Technology Education* (N = 26) and *Clinical Anatomy* (N = 21). The languages of included documents included English (N = 1265), Spanish (N = 72), Portuguese (N = 6), Russian (N = 6), Turkish (N = 6), Ukrainian (N = 3), German (N = 3), Chinese (N = 2), Hungarian (N = 1), and Slovak (N = 1).

3.4. Procedure of Data Analysis

The procedure of the content analysis was as follows. First, we made use of the citation report in the Web of Science tool, and the times cited and publications over time were provided. Based on the citation report, we analyzed the publication trend of the search topics. Second, 1275 selected articles were inputted into VOSviewer. Later, we chose the co-occurrence analysis to bibliometrically analyze the top ten authors, sources, organizations, and countries. According to the co-occurrence result, we analyzed the situation of AR learning development. Third, we imported the 1275 articles into CitNetExplorer to bibliometrically analyze the citation network. The author's information, title, and source could be found in CitNetExplorer. Then, we chose two publications to drill down to deter-

mine the longest path. In this way, we found out the common focus of the publications in the longest path. Based on the focus, we explored the answers in the publications.

4. Results

RQ1: What is the year-based trend of included publications and citations?

The survey results showed the number of annual publications, which were used to analyze trends in the included and cited articles. The survey results included 123 review articles and 394 open access articles covering the period ranging from 2008 to 2022. Figure 1 shows that research on AR in language learning has been growing since 2008, when research on AR in language learning was born. The number of relevant studies fluctuated between 2008 and 2010, but suddenly increased in 2011. From 2011 to 2014, the number of relevant studies also fluctuated up and down. From 2015 to 2021, the number increased steadily and reached a peak in 2022. Since then, the number of relevant research has gradually increased. Between 2019 and 2022, there is a large number of publications on the topic of AR in language learning. From the birth year of AR until 2022, the number of citations continues to increase, especially in 2020 and 2021. Therefore, according to the publication trend, the topic of the use of AR in language learning will continuously be a hot issue. Future researchers can target their research directions based on the figure below.

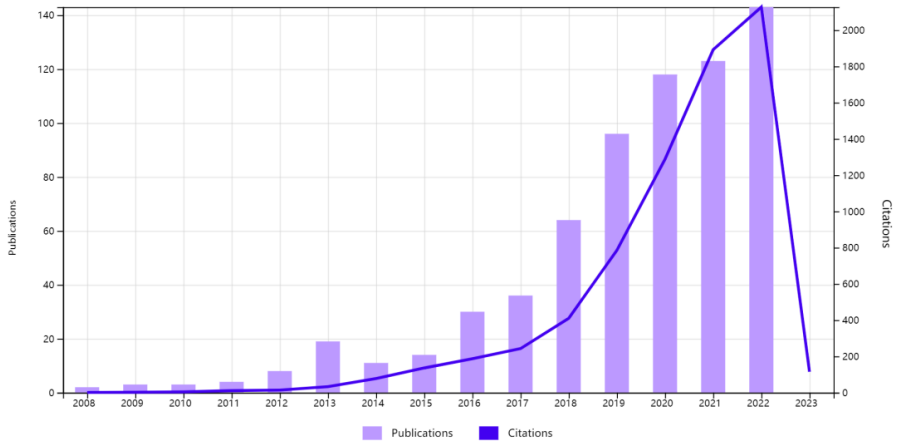

Figure 1. Times cited and publications of search topics over time.

RQ2: What are the top ten authors, sources, organizations, and countries among the studies on AR in language learning?

To fill the research gaps in each country, we identified the most cited authors, sources, organizations, and countries in this field using VOSviewer (see Table 3). In addition, we clustered the citation strength of the most cited authors, sources, organizations, and countries that contribute most to the field. It is important to note that researchers can find a large number of high-cited published citations from these highly cited sources. The cluster analysis provides a comprehensive overview of the most cited studies.

As Table 3 shows, the top ten cited authors are Chang Hsin-Yi, Lee Silvia Wen-Yu, Liang Jyh-Chong, Wu Hsin-Kai, Akcayir Gokce, Akcayir Murat, Baldiris Silvia, Kinshuk, Bacca Jorge, and Fabregat Ramon. The top ten cited sources are *Computer & Education*, *Educational Research Review*, *Educational Technology & Society*, *Computers in Human Behavior*, *Personal and Ubiquitous Computing*, *Eurasia Journal of Mathematics, Science and Technology Education*, *International Journal of Environmental Research and Public Health*, *Interactive Learning Environments*, *Education Science*, and *Clinical Anatomy*. The top ten organizations are National Taiwan University of Science & Technology, National Taiwan Normal University, National Changhua University of Education, National Kaohsiung Normal University, Kirikkale University, Gazi University, University of Girona, Athabasca University, University of La Laguna, and University of Granada. The top ten countries are the USA, Spain,

Taiwan, Turkey, the People's Republic of China, Canada, Australia, South Korea, England, and Greece.

Table 3. Top ten authors, sources, organizations, and countries.

N	Cited Author	Citation	Link	Cited Source	Citation	Link
1	Chang, Hsin-Yi	860	316	*Computers & Education*	1841	221
2	Lee, Silvia Wen-Yu	860	316	*Educational Research Review*	636	134
3	Liang, Jyh-Chong	860	316	*Educational Technology & Society*	480	89
4	Wu, Hsin-Kai	860	316	*Computers in Human Behavior*	315	50
5	Akcayir, Gokce	577	351	*Personal and Ubiquitous Computing*	302	50
6	Akcayir, Murat	577	351	*Eurasia Journal of Mathematics, Science and Technology Education*	288	26
7	Baldiris, Silvia	565	378	*International Journal of Environmental Research and Public Health*	256	31
8	Kinshuk	565	378	*Interactive Learning Environments*	207	64
9	Bacca, Jorge	565	378	*Education Science*	160	68
10	Fabregat, Ramon	524	308	*Clinical Anatomy*	158	21
N	**Organization**	**Citation**	**Link**	**Country/Region**	**Citation**	**Link**
1	National Taiwan University of Science & Technology	919	180	USA	2042	332
2	National Taiwan Normal University	912	205	Spain	1877	397
3	National Changhua University of Education	873	184	Taiwan	1370	248
4	National Kaohsiung Normal University	860	177	Turkey	1212	388
5	Kirikkale University	578	227	People's Republic of China	635	216
6	Gazi University	577	217	Canada	616	159
7	University of Girona	526	178	Australia	450	75
8	Athabasca University	508	165	South Korea	374	70
9	University of La Laguna	451	73	England	286	83
10	University of Granada	365	132	Greece	236	170

Five clusters were identified based on the clustering methods in CitNetExplorer. Publications were clustered based on citation links. After selecting the 100 most cited publications in the citation network visualization, Figure 2 was created, which contains 1275 publications (only 100 could be visualized) and 10,890 citation references. Due to the defined minimum size, 94 publications were not included in the clustering. Table 4 shows the number of publications in each group, number of citations, number of publications cited more than 20 times, and number of publications in the top 50 most cited (see Table 4). The citation network covers the period ranging from 1951 to 2022.

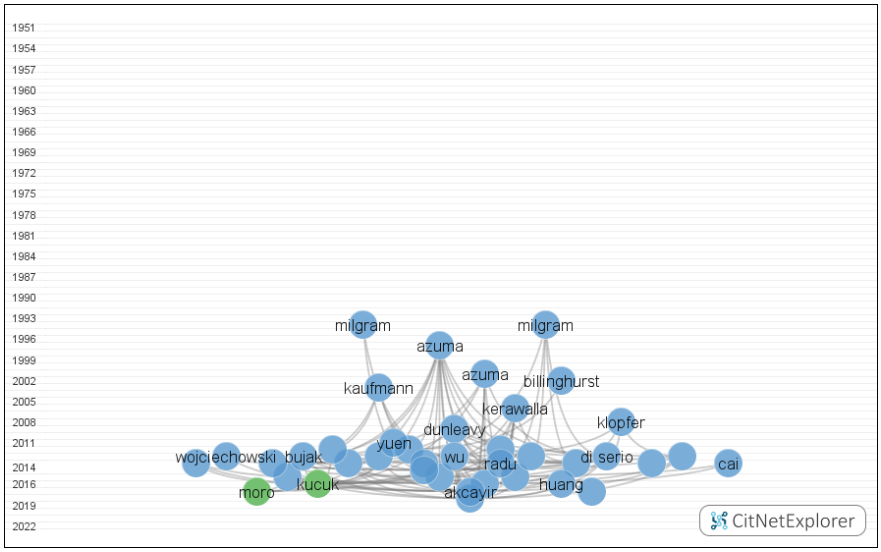

Figure 2. Visualization of citation networks.

Table 4. Five clusters and citation networks.

Cluster	Color	No. of Publications	No. of Citation Links	No. of Publications ≥ 20 Citations	No. of Publications in 50 Most Cited Publications
1	Blue	830	7193	104	40
2	Green	192	716	12	3
3	Purple	89	352	7	0
4	Brown	48	157	3	7
5	Yellow	14	17	0	0

RQ3: What are the users' attitudes toward AR tools?

The authors used CitNetExplorer to drill down the longest paths. It is generally accepted that the longest path between two articles indicates the citation relationship between them and reveals hot topics in the research area. After searching for the longest path, the authors identified the citation relationships of 11 publications in Figure 3. AR-enhanced education was first proposed as a teaching approach by [29]. According to [30], the co-citation network of cited authors can show a connected focus among these authors in a given field. The other publications mainly focus on the analysis of technologies, strategies, and methods of using AR tools, as well as the evaluation and attitude toward AR. Thus, it indicates that the integrated method of AR tools and attitude toward AR are popular topics in the research field.

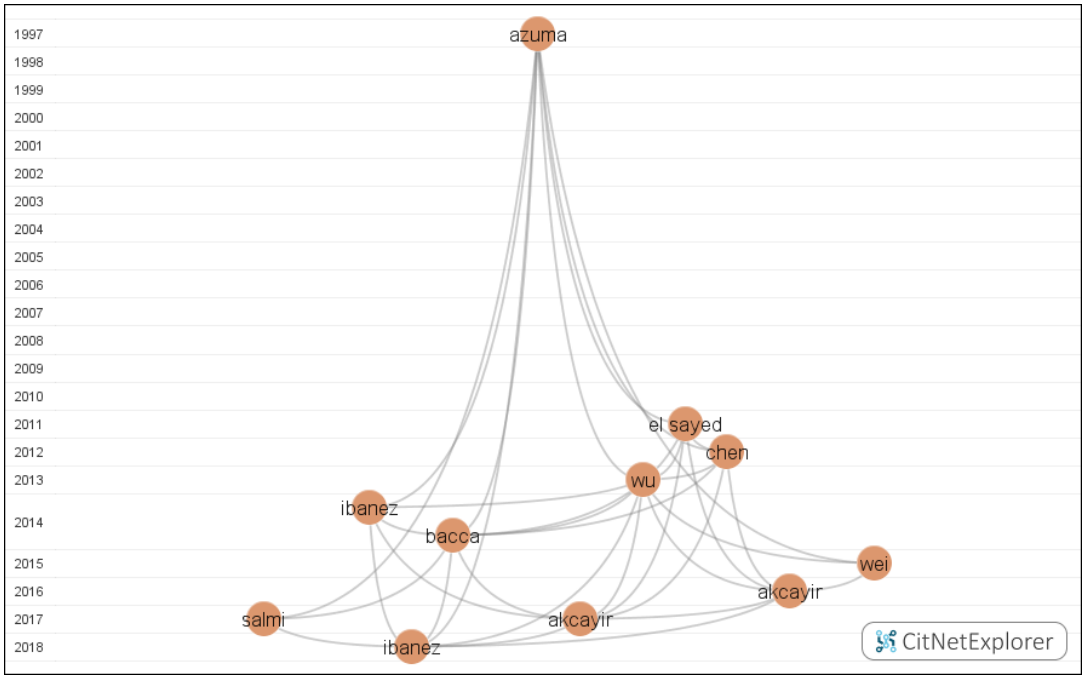

Figure 3. Visualization of the first longest path analysis.

AR technology combines elements of real and virtual content and has the potential to address the lack of real-life scenarios outside of the classroom. According to [31], attitude was the second most influenced emotional state in AR learning environments. The author also found that AR can foster students' positive attitude toward learning, which can promote their performance. Ref [32] pointed out that most students in their study hold a positive attitude toward the use of AR in their language learning; they thought it was enjoyable to learn through play. Ref [33] proposed that children often enjoy augmented reality media and that this has a positive impact on their learning. After experiencing AR tools in the classroom, students showed a clear tendency to prefer them as language learning tools and showed more interest in the learning process [34]. However, the use of

augmented reality in the classroom is not limited to the learner but instead largely depends on the teacher's willingness and ability to use it effectively [2].

Ref [35] noticed the important interaction between teachers' attitudes and intentions and found that a positive attitude toward AR-supported instruction influences its continued application in the classroom. They found that teachers' positive attitudes toward the application of AR included satisfaction, appropriateness, reliability, and belief. Positive attitudes toward AR technology predict future educators' digital confidence in implementing AR. In previous studies [36], the ratings of reliability in AR use were higher than the ratings of satisfaction and relevance. However, the new dimension "belief" was significantly better than the other three dimensions. This suggests that teachers are convinced of the need to integrate augmented reality into teaching, including in content creation and visualization in the coming years.

RQ4: How are AR tools integrated with language teaching and learning?

Except for the attitude toward the use of AR, the publications in the first longest path (Figure 3) also commonly discussed the ways to integrate AR with language teaching and learning. According to [37], the AR systems that are currently used are portable technologies, which can improve the immersion experience. As the authors mentioned, TimeLab2100, which provides real-world locations (e.g., a subway station and a park), can help students find a substitute for their learning needs. Ref [32] found that the well-integrated ways, including images, texts, and videos, could better prevent students' cognitive loads and improve their academic performance. Ref [38] proposed a new way to integrate AR tools with language learning. The authors designed an AR library institution system that combines 3D technology and a library environment to teach students skills. This innovative way can improve teachers' teaching effectiveness and make it attractive for students to learn.

Augmented reality tools are closely related to different aspects of language learning. In a study by [39], HP Reveal, a platform that delivers virtual content to users through mobile devices, was identified as the most widely used tool for computer-assisted learning. Teachers use this advanced platform to convert images into 3D and allow students to visualize learning material. In addition to HP Reveal, some researchers have used Vuforia, an augmented reality application, and Unity, a game engine used in language studies, to develop learning content. Teachers can use these two tools to create AR content for language learning. Ref [39] also mentioned that learner immersion should be the main focus of language learning in augmented reality research.

AR enhances language learning by providing learners with virtual elements that are superimposed upon the real environment in the way of 3D images, movies, and games. AR applications can provide 3D images with sound and movement and are often used to teach vocabulary and writing. In a study by [40], an AR app with 3D images was used to teach brushstroke spelling via animation. It helped students learn by explaining step-by-step how to write Chinese characters, and the tool developed their spelling acuity. In addition, AR videos have also been used to foster language learning. Ref [41] conducted a study using AR videos to support students' English language learning. When students studied language with the AR tool, an AR video of the corresponding objects appeared on the screen. The results showed that this helped students learn the learning material in a clearer and more concrete way, which significantly improved learning outcomes. Augmented reality games have also been integrated into language learning. According to [39], the most widely used games for language learning are Pokémon Go and ChronoOps. Pokémon Go and ChronoOps are location-based augmented reality mobile games. In the game scenarios, students can learn the language by looking at the names of three-dimensional objects and listening to their pronunciation.

RQ5: What are the effects of AR on language learning?

To answer this question, this study drilled down the publications and created another citation network according to [9] (see Figure 4). This citation network consisted of eight publications. After eliminating studies similar to the first longest path, we focused on those

by [31,37,42–44]. It was found that all eight of these publications discussed the effects of the use of AR tools. These articles mainly focus on students' motivation, interests, and performance. Ref [42] developed an AR-supported learning system called HELLO, which aims to improve students' language skills. The results showed that the AR-supported system can provide more learning resources for students and provide enjoyable learning experiences. Based on the results, it was concluded that the use of AR tools has an effect on language teaching and learning. Ref [37] also explored the learning effects of AR tools; the authors thought that, when compared with other technology-supported environments, an AR system can help learners to improve their language skills in a more effective way. It can show learners the learning content in a 3D method so that learners can manipulate the virtual objects interactively. According to [45], the engagement and enjoyment of students are high when in an AR-enhanced environment. The students tended to have a higher level of concentration when they dealt with the tasks.

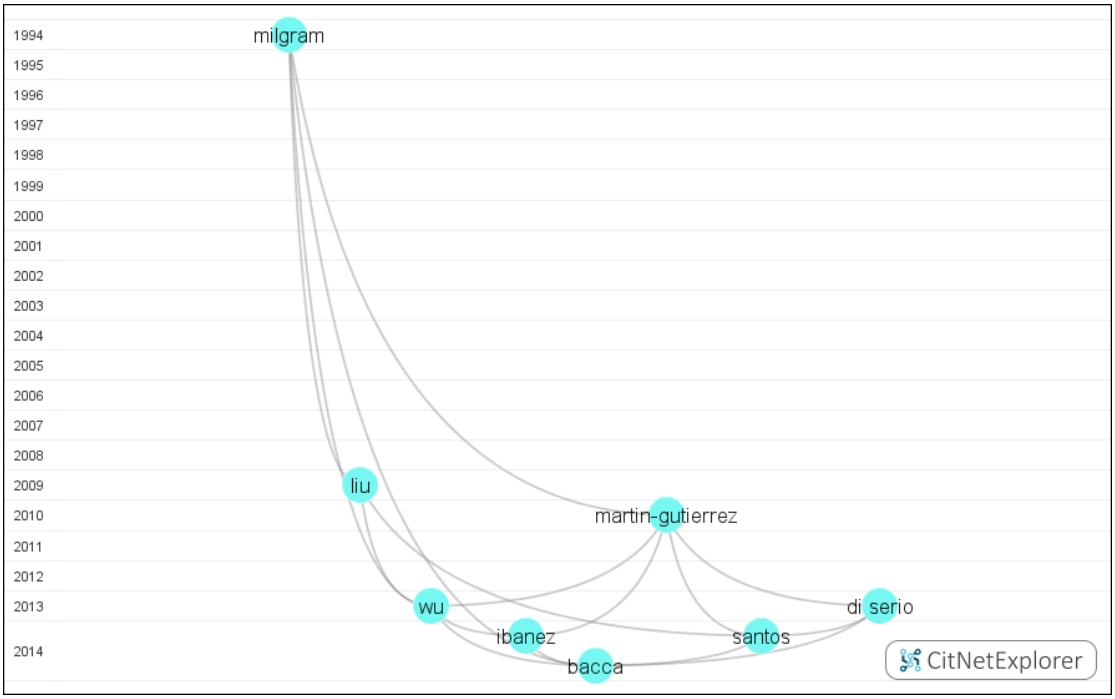

Figure 4. The visualization of the second-longest path analysis.

The main findings on the benefits of augmented reality are students' better learning outcomes [45]. Augmented reality technology can improve language skills and academic performance compared with traditional teaching methods. Learners who used information visualization showed a significant improvement in learning speed and quality and thus in their learning outcomes. According to [46], the use of AR technology in language teaching improves students' performance and makes vocabulary learning more effective. Moreover, the use of AR tools can also make a difference in the learner's emotions. On the one hand, it can improve students' positive emotions, such as satisfaction, enthusiasm, interaction with the environment and people, motivation, and positive perceptions of augmented reality use, making learning more effective [21,45]. On the other hand, it can also reduce learners' anxiety, increase their creativity, and foster their cooperation [39,47]. Therefore, it is noteworthy that the implementation of AR technology can have a significant positive impact on students' motivation to learn [48].

However, the use of AR tools can also cause some problems. Ref [37] found that if students are not offered well-designed interfaces, they will experience difficulty using the AR tools and understanding the information in the AR devices. Moreover, students will face the problem of cognitive overload because they have to deal with abundant information

and complex technology. In this way, students will become overwhelmed and stressed when they face these complex tasks. Ref [42] also noticed the constraints of using AR tools in that the current technology of AR is not enough to be applied in classes because of its insufficient memory, lower computing efficiency, and so on.

5. Discussion

RQ1 and RQ2 were devoted to the bibliometric analysis of the trend of AR tools in language learning. The annual trends of collected publications and citations can provide clear guidance for future research. RQ1 showed the trend of the research in the use of AR tools in language learning, which indicated its increasing popularity in the research field. Therefore, more research needs to be conducted in this area. The result of RQ2 showed the top ten authors, sources, organizations, and countries; it indicated that the development of AR tools in language learning is booming in the USA, Spain, Taiwan, and Turkey. Except for the USA and Spain, other countries, such as China, Australia, and Canada, are increasingly promoting their studies in AR learning. The study also figured outdetermined that the study of AR teaching and learning has led to more attention from researchers in Asian areas, and more studies from Asian organizations have promoted the development of AR learning in language learning. Additionally, the journal *Computers & Education* has contributed most to the development of AR learning. Therefore, researchers who are interested in AR teaching and learning would do well to analyze publications in *Computers & Education* for information on future research topics to fill gaps in previous research.

RQ3 was used to determine users' attitudes toward AR tools in language learning. Through the analysis of the first longest path, we found that both learners and teachers were in favor of using augmented reality in language learning. This could be attributed to the learner's self-perception of their improvement of language skills and their relief of negative emotions. This is consistent with previous studies. According to [47], the use of AR can help students reduce their anxiety levels, increase their creativity, and fosters collaboration and engagement in their real-life language environment. Therefore, learners tend to behave actively toward the use of augmented reality for learning English. A technology-enhanced approach was positively evaluated by students, as it enriched their language learning experience and at the same time increased their language awareness [49]. Thus, in future education, teachers should think about the method to develop students' positive attitudes toward modern teaching methods, which can be considered as a key factor for the integration of AR into language [35]. Moreover, educational institutions in the future should try to cultivate teachers' positive attitudes toward AR, which can appear to predict their perceptions of content creation and visualization using AR tools.

RQ4 explained the ways to integrate AR into language learning. The integration of AR tools in language learning is a key factor in the development of language skills. It was found that the most widely used augmented reality learning tool is HP Reveal, Vuforia, and Unity. In addtion, the well-integrated ways include 3D images, texts, games, and videos. A study found that these tools, when combined with games, can increase learners' motivation to learn [4]. One possible reason is that both games and AR tools focus on interaction, which plays a key role in language learning. For learners, they can use these language skills when interacting with the real world. The result may also be due to the rich scenes, voices, and characters in 3D images and videos, which make students more concentrated on the learning content itself and make the class more enjoyable to interact with. However, the limitation is that although the research on AR learning is continuously increasing, the actual use of AR tools in language has not been widely used in most schools. Therefore, the real effects of the integrated ways still need to be repeatedly verified.

QR5 investigated and proved the effect of AR on language learning. Augmented reality tools play an important role in language learning because they improve learners' performance, increase their motivation, and perceive the use of augmented reality positively. As a result of the AR-enhanced language learning, students' attitude toward learning English significantly improved and their self-efficacy in using English increased [48]. More-

over, the integration of AR tools in language learning contributes to the development of language knowledge and skills [39]. This result may be explained by the fact that immersive learning and increased motivation are the most important factors in language learning. By interacting with virtual information, learners gain a sense of immersion. As the use of AR allows for a deeper understanding of the learning material, learners can perceive things better in a context. In addition, learners feel relaxed and interested when interacting with AR tools. This stimulates their interest in learning and helps them increase their motivation to go deeper into the language. However, the use of AR tools can also cause some problems, such as cognitive overload on the students and the complexity of operation. This result has barely been described in previous research.

6. Conclusions

This part mainly includes the major findings, limitations, and implications for future research.

6.1. Major Findings

This study combined qualitative and quantitative research methods to analyze the use of AR in language learning. It summarized trends in the use of AR tools in language learning, users' attitudes toward AR tools, ways of integrating AR into language learning, and the effectiveness of the AR tools. The results of the study are based on longest path analysis. The yearly trends in the number of publications and citations showed increasing numbers in the field of AR in language learning, which indicated a bright prospect for the development of AR learning. This is consistent with the findings of [1] in that technology-supported language teaching will be offered more opportunities in future educational systems. At the same time, the top ten published authors, sources, organizations, and countries also indicated different research directions and priorities and provided an important point of reference for future researchers.

In terms of users' attitudes, both teachers and learners show positive attitudes toward the use of AR in language learning. Through the use of augmented reality tools, students showed more interest in the teaching and learning process [33]. Teachers' positive attitudes toward AR-supported teaching and learning influence their consistent use of AR in the classroom. Thus, their positive emotions make it easier to conduct the teaching activities and improve academic performance [24]. AR enhances language learning through 3D images, texts, videos, and games. The most widely used augmented reality learning tool is HP Reveal [4], an artistic platform that provides users with virtual content via their mobile devices. Research has shown that AR tools can facilitate language learning and improve students' performances by providing an immersive learning experience, increasing motivation, and reducing learning anxiety [4]. This finding agrees with the previous studies [21,23], which proved that the use of AR tools can have a positive effect on the learning process of students. However, there are also some disadvantages of the use of AR in language learning, such as cognitive overload and the complexity of operation [37]. Therefore, teachers need to pay attention to the use of AR in the teaching process.

6.2. Limitations

Due to the authors' limited knowledge, there are some limitations. First, because this study did not register for a protocol, there may be cognitive bias in the process of the analysis. Second, the study may not contain all related publications because CitNetExplorer can only analyze the resources from the Web of Science. Third, this study only analyzed positive attitudes toward the use of AR; there may also be a few studies about negative emotions toward AR tools. Moreover, there may be other ways to integrate AR tools with language learning. However, this study only introduced the three most common approaches, which are 3D images, videos, and games. More advanced ways should be further explored in the future. Lastly, this study mainly analyzed the effect of AR on language learning for students. With the help of AR tools, students can improve their

language skills and knowledge. However, whether or not the use of AR in language teaching can exert an influence on teachers was not involved in this study.

6.3. Implications for Future Research

The findings indicate that a positive attitude plays an important role in AR-enhanced language learning. Therefore, in the future educational field, teachers should cultivate students' interest of learning language through the use of AR tools. In turn, students can improve their performance in language learning with the help of AR tools. Additionally, the findings also show that AR enhances language learning through the use of 3D images, texts, videos, and games. Thus, when future teachers conduct their vocabulary teaching with AR tools, they can present the words using 3D images in order to deepen students' understanding and memorization of these words. According to this study, the lack of real context affects students' language learning. At this point, AR can solve this problem by helping learners see virtual objects that are composited within the real environment. Therefore, to foster students' cognitive development of language learning, the future educational system can apply teaching activities that are supported by AR in the language teaching process.

Future research should realize the importance of educators' and practitioners' attitudes. This study found that both educators and students have positive attitudes toward the use of AR in language learning. Therefore, in terms of educators and educational institutions, the factors that contribute to the formation of positive emotions should have more attention paid to them. Furthermore, future studies should explore whether negative emotions exist with respect to the use of AR tools. The reasons for the negative emotions should also be explored, which will make sense for future language education. Both teachers and students should notice that their attitude toward AR tools will directly affect their perception and mastery of language skills. Additionally, further educational practices could explore the attitude of different age groups and different educational levels based on this study.

With the technological advancement in AR, more and more AR applications will be invented, and integration with AR tools will become a major approach. Thus, future studies can explore the effectiveness of various AR applications. Researchers can think about more approaches for different educational levels to integrate new versions of AR tools for language learning. In the future, researchers could explore the effect of the use of AR tools in language learning from the perspective of educators. According to this study, educators' attitudes toward AR-enabled instruction affect their continuous use in the classroom. Therefore, future studies can collect teachers' feelings and feedback about the AR tool, upon which more effective AR applications can be invented.

Author Contributions: Conceptualization, Z.Y.; Methodology, W.M.; Investigation, W.M.; Writing—original draft, W.M.; Writing—review & editing, W.M.; Funding acquisition, Z.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This work is supported by 2019 MOOC of Beijing Language and Culture University (MOOC201902) (Important) "Introduction to Linguistics"; "Introduction to Linguistics" of online and offline mixed courses in Beijing Language and Culture University in 2020; Special fund of Beijing Co-construction Project-Research and reform of the "Undergraduate Teaching Reform and Innovation Project" of Beijing higher education in 2020-innovative "multilingual +" excellent talent training system (202010032003); The research project of Graduate Students of Beijing Language and Culture University "Xi Jinping: The Governance of China" (SJTS202108).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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Exploring Undergraduate Students' Digital Multitasking in Class: An Empirical Study in China

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Abstract: UN's 2030 Agenda for Sustainable Development highlights the crucial role of education in securing a promising future for humanity, especially in today's digital era. However, the prevalence of smartphones has fostered an increase in students' usage and subsequent digital multitasking tendencies, posing a significant threat to education process, especially in higher education. To gain further insights into this phenomenon, this exploratory descriptive study surveyed 519 students from China university to investigate the magnitude of students' digital multitasking, motivation behind digital multitasking, and beliefs about reducing phone use. The study found that, (1) despite many respondents reporting the existence of phone limits, no possible reduction in phone use frequency was observed; (2) digital multitasking was positively correlated with mobile phone dependence and non-study motivation; (3) while a majority (86.71%) students expressed their intent to reduce digital multitasking, they were mostly hesitant to follow the moderate or strict rules on phone use; (4) no clear consensus was established (49.90% vs. 50.10%) regarding whether schools should pose more restrictions to encourage such reduction. Our research provides further insights into students' digital multitasking to improve learning quality and sustainable education.

Keywords: digital multitasking; smartphone use; motivation

Citation: Wang, Q.; Sun, F.; Wang, X.; Gao, Y. Exploring Undergraduate Students' Digital Multitasking in Class: An Empirical Study in China. *Sustainability* **2023**, *15*, 10184. https://doi.org/10.3390/su151310184

Academic Editors: Barry Lee Reynolds, Rustam Shadiev and Rui Li

Received: 22 May 2023
Revised: 10 June 2023
Accepted: 25 June 2023
Published: 27 June 2023

1. Introduction

Currently, the younger generation has grown up in an environment emerged in electronics and technologies, with much more exposure to these digital devices than any other generations. In modern China, the penetration rate of the internet and smartphones has reached a new high level, and almost all the Chinese university students are equipped with smartphones [1]. Zooming out, the current landscape in universities around the world shows the same increasing trend in smartphones [2]. Mobile phones in the classroom allow students to record audio or video, take pictures of lecturers' instructions on the board or screen, share study-related documents among their peers, and enhance communications with teachers beyond the class. Mobile phones have provided essential assistance to college students in class [3–5], in finishing coursework [6], and in exam preparation [7]. As digital natives, students believe that smartphones have become an integral part of their lives [8].

On the other hand, the accessibility to smartphones in class has posed challenges to sustainable education, owing to the tendency of students to undertake non-study-related activities [9,10]. Universities in different countries, such as France, America, and Australia, have tried to ban smartphones in class [11]. In such circumstances, increasing attention has been paid to the investigation of students' digital multitasking in class—a behavior that involves using a digital device while simultaneously engaging in a different activity [12–15]. Despite the fact that, in certain cases, digital multitasking would not impact students' learning process [16], a number of the downsides of digital multitasking were reported in higher education. For example, researchers have found that digital multitasking could facilitate

the development of a "checking habit", which could impact students' concentration [17], generating distractions and course work conflicts [18], and even influencing overall college GPA [6,19–21]. Meanwhile, many researchers tried to examine the nature and the major mediator behind such behavior [22]. For instance, researchers believed that more exposure to digital devices would cause physical stimulation to students and then increase the tendency of digital multitasking in class, called "technology addiction" [11]. Rozgonjuk et al. found that fear of missing out (FOMO) was a key mediator in influencing students' learning process [23].

Although studies have been conducted to analyze digital multitasking, it is worth noting that only showing the downsides of digital multitasking is insufficient for improving students' overall academic performance. Some studies tried to employ interventions to reduce students' digital multitasking but failed to achieve that goal [24,25]. Furthermore, some studies [8,23] only took social media as a lens to investigate the impact and the nature of digital multitasking, which means that more factors should be included to better understand such behavior.

To address these research gaps, this study draws upon Brown's behavior addiction components, which encompass symptoms such as cognitive salience, withdrawal, and loss of control [26,27]. This framework was adapted to measure engagement with technology integration [28]. On the basis of this theory, Walsh et al. developed the Mobile Phone Involvement Questionnaire for assessing respondents' dependence on their phones [28]. By applying the behavior addiction theory and utilizing the model developed by Walsh et al., this study examined students' mobile phone dependence and its relationships among other factors.

In the current digital age, exploring the nature of students' digital multitasking is essential for achieving sustainable development in higher education. Therefore, this study adopted quantitative approach to gain insights into undergraduate students' digital multitasking in class. Specifically, the goals of the present study were to investigate (1) the magnitude of students' digital multitasking, (2) motivation behind digital multitasking, and (3) beliefs about reducing phone use.

2. Materials and Methods

2.1. Research Design

This study employed a quantitative approach to investigate digital multitasking among Chinese undergraduate students during class, with the aim of promoting sustainable higher education. The primary focus of the present study was to explore the magnitude of students' digital multitasking, motivations behind students' digital multitasking, and beliefs about reducing phone use. Additionally, the study examined the relationships among these variables. To obtain data, students were invited to complete an anonymous online-based questionnaire specifically designed to assess their digital multitasking practices. The quantitative data collected were subsequently analyzed using statistic software, and the findings were reported accordingly.

2.2. Participants

In this study, the population of interest was undergraduate students in China. We adopted convenience sampling and online-based snowball sampling to gain insights into students' digital multitasking in class. A total of 634 online-based questionnaires were collected. A total of 72 questionnaires were excluded because of attention check failure; 38 questionnaires were excluded because the respondents claimed that they were not undergraduate students; five questionnaires were excluded because the same responses were presented among all the items in all the sectors. In total, 519 questionnaires were established for further analysis. The demographic profile of the respondents is presented in Table 1. Among all the respondents, 85 students were identified as being from "985 Project" universities, which are classed as the top universities in China (Tier A); 74 students were identified as being from "211 Project" universities, which ranks lower than the "985

Project" regarding their comprehensive abilities (Tier B); 159 students were identified as being from "double first-class" universities, the emerging institutions in recent years (Tier C); 147 students were identified as being from mainstream public universities (Tier D); 54 students remained confidential.

Table 1. Sample demographics.

	n	%
Gender		
Male	206	39.7
Female	313	60.3
Age		
19 and below	216	41.6
20	71	13.7
21	77	14.8
22	85	16.4
23 and above	70	13.5
Year of study		
1st	198	38.2
2nd	87	16.8
3rd	93	17.9
4th	141	27.2
University level		
Tier A	85	16.4
Tier B	74	14.3
Tier C	159	30.6
Tier D	147	28.3
Confidential	54	10.4
Field of study		
Arts and humanities	144	27.7
Social sciences	89	17.1
Natural sciences	114	22.0
Engineering	122	23.5
Others	50	9.6

Specifically, the largest majority of respondents were female students (60.3%), in their first year (38.2%), and majoring in arts and humanities (27.7%). As shown in the age breakdown, most participants were 19 or below (41.6%).

2.3. Data Collection

In this study, students were asked to complete an anonymous online-based questionnaire. The first page of the questionnaire served as a consent form, informing the students of the purpose of this study and ensuring that all the responses would remain anonymous. Students were also informed that this study was completely voluntary, and that they could quit from the study at any time. The data collection lasted from 11 November 2022 to 22 November 2022. At the time of the study, all of the participants had experienced face-to-face class and were able to describe their smartphone use in class.

2.4. Instruments

In the present study, the measure consisted of three sections: (1) the magnitude of students' digital multitasking, (2) motivation behind digital multitasking, and (3) beliefs about reducing phone use. All the instruments were originally presented in Chinese and then translated into English for further investigation. All the translated scripts were quality-checked and double-checked by all the authors. Furthermore, to reduce any order effect bias in the questionnaire, all three sections were presented randomly.

2.4.1. The Magnitude of Students' Digital Multitasking

Restrictions on phone use. This measure intended to investigate students' perception on school restrictions of phone use. Moreover, it was assumed that school restrictions in class may impact students' behavior regarding digital multitasking. To assess such possible influences and perception, the respondents were asked: "In your school, are there any restrictions during class?" (yes or no). If yes, we then asked, "Do you follow school rules that restrict in-class smartphone use?", with students responding on a scale from 1 (never) to 5 (very often).

Frequency of phone use. This measure consisted of two items: (1) "How often do you use your mobile phone during class in a school day?" (2) "How often do you use your mobile phone during class for *non-course-related activities* in a school day?" The respondents were asked to describe their frequency of phone use on a scale from 1 (never) to 5 (very often). This means that students with higher scores in total used their phone more in general or for non-study purposes in a school day.

2.4.2. Motivation behind Digital Multitasking

Mobile phone dependence. The Mobile Phone Involvement Questionnaire (MPIQ) is aimed at assessing respondents' phone dependence using an eight-item measurement [28]. Students were asked to rate each item on a scale from 1 (strongly disagree) to 6 (strongly agree).

Motivation behind phone use. Olufadi revealed six types of motivations for smartphone use in class [29]. In the present study, we presented five possible motivations, four of which were inspired by Olufadi's work, and then asked the students to rate how frequently each reason was the motivation for their phone use on a scale from 1 (never) to 5 (very often). The five items in English were as follows: I use my phone . . . (1) " . . . to chat with others" (social connection), (2) " . . . just to kill time" (boredom), (3) " . . . to entertain myself but I believe it will not affect my concentration" (perceived behavioral control), (4) " . . . to take notes or search for course-related information" (class-related use), and (5) " . . . to learn other courses". According to the different contents of each motivation, we marked motivations (1), (2), and (3) as "non-study motivations", while (4) and (5) were considered "study-related motivations".

2.4.3. Beliefs about Reducing Phone Use

Intention to minimize phone use. Two items were included in this measure: (1) "I should reduce the frequency of phone use in class or try to never use it"; (2) "I think the school should introduce more methods to help me reduce my phone use". The respondents were asked to rate these two items on a scale from 1 (strongly disagree) to 6 (strongly agree).

Receptivity to strategies for reducing digital multitasking. Students were presented with four strategies to possibly reduce their digital multitasking during class, and then asked whether they would be willing to adopt these strategies. Specifically, the respondents were told, "The following strategies might help you concentrate more and reduce your phone use in class. Which one would you like to follow?": (1) put your phone into silent or flight mode; (2) put your phone somewhere unseen but within your reach (i.e., schoolbag, handbag, or drawer); (3) take no phone with you or put your phone someplace beyond your reach (i.e., designated storeroom or lockers outside of the classroom); (4) turn off your cellphone. According to the accessibility to their cellphones (whether students could use their phone immediately), we marked methods (1) and (2) as "moderate strategies", and methods (3) and (4) as "strict strategies".

2.5. Data Analysis

For the analysis of the collected data, this study employed a quantitative analysis approach using the Statistical Package for the Social Science (SPSS) software version 26 and Microsoft Excel 2019. A total of 519 questionnaires were identified for further analysis.

Initially, the internal reliability of the instruments was assessed using Cronbach's alpha coefficient. The calculated value of Cronbach's alpha was found to be 0.827, indicating a high level of internal reliability of the questionnaire instruments.

Descriptive statistics, including means (M), standard deviations (SD), frequencies, and percentages, were calculated to provide a comprehensive landscape of Chinese undergraduate students' digital multitasking magnitude, motivation, and beliefs about reducing phone use. These statistics summarized and presented the detailed responses from the participants, allowing for a clearer understanding of the data.

Furthermore, Spearman's rho coefficients (r_s) were computed to explore the relationships among different variables. This statistical enabled the exploration of correlations among the variables of interest.

3. Findings

This section provides an overview of the three measurements applied in the present study. Frequency and percentage for all specific responses are reported, while correlations among different variables were analyzed utilizing Spearman's rho coefficients.

3.1. The Magnitude of Students' Digital Multitasking

Restrictions on phone use. Of all the respondents, 54.72% (284) claimed that there was no rule restricting phone use in class. Out of the remaining 45.28% (235), 48.51% (114) reported that they would always adhere to the restrictions in class, while 29.36% (69) indicated they would often follow the rules. In sum, 64.74% (336) respondents had no rules or barely followed the rules in class.

Frequency of phone use. Table 2 presents the frequency of phone use among those who did not face restrictions or barely followed them in class, with a sample size of 336. According to the table presented, a significant number of respondents (82.74%, 278) reported using their phones often or very often in class, while only a small percentage (3.87%, 13) claimed that they never or rarely used smartphones in class. Furthermore, among all the participants involved, 58.93% (198) used smartphones often or very often for non-study purposes during class.

Table 2. Frequency of phone use.

	Never [a]	Rarely [b]	Sometimes [c]	Often [d]	Very Often [e]
Frequency of ...					
Phone use	4 (1.19%)	9 (2.68%)	45 (13.39%)	107 (31.85%)	171 (50.89%)
Non-study purposes	5 (1.49%)	40 (11.90%)	93 (27.68%)	109 (32.44%)	89 (26.49%)

Note: [a] Students never used mobile phone in class. [b] Students used their mobile phone 1–3 times a day. [c] Students used their mobile phone 4–10 times a day. [d] Students used their mobile phone 11–30 times a day. [e] Students used their mobile phone over 30 times a day.

The findings revealed that school restrictions in class may not have a significant impact on reducing students' phone use. Although it was assumed that such restrictions could possibly achieve that goal, the qualitative analysis did not suggest any possible correlation between the frequency of phone usage and the implementation of phone restrictions.

3.2. Motivation behind Digital Multitasking

Students' mobile phone dependence. Table 3 presents Walsh's MPIQ [28] results of students' mobile phone dependence. Data in the present study were in line with the trend in Walsh's work, with "withdrawal" being the most commonly endorsed (M = 4.12, SD = 1.52) and "interpersonal conflict" being mostly opposed (M = 2.72, SD = 1.50).

Motivation behind digital multitasking. Table 4 presents the data on motivation behind students' digital multitasking in class. Among the five motivations listed, the most commonly cited motivation was to take notes or search for course-related information (M = 3.40, SD = 1.06), with 49.7% of students reported being "often" or "very often". Additionally, students also reported other motivations for using mobile phone during class. These

motivations included to chat with others (M = 3.12, SD = 1.15), just to kill time (M = 3.12, SD = 1.20), to entertain myself but I believe it will not affect my concentration (M = 2.65, SD = 1.13), and to learn other courses (M = 2.78, SD = 1.22).

Table 3. Students' mobile phone dependence.

Categories	M	SD
Cognitive salience	3.82	1.38
Behavioral salience	4.08	1.38
Interpersonal conflict	2.72	1.50
Conflict with other activities	3.20	1.35
Euphoria	3.75	1.38
Loss of control	4.02	1.48
Withdrawal	4.12	1.52
Relapse and reinstatement	3.84	1.40

Table 4. Motivation behind students' digital multitasking.

Motivation (I Use My Phone . . .)	Never	Rarely	Sometimes	Often	Very Often
To chat with others	53 (10.2%)	98 (18.9%)	156 (30.1%)	157 (30.3%)	55 (10.6%)
Just to kill time	63 (12.1%)	96 (18.5%)	136 (26.2%)	163 (31.4%)	61 (11.8%)
Entertain myself but I believe it will not affect my concentration	97 (18.7%)	137 (26.4%)	161 (31.0%)	100 (19.3%)	24 (4.6%)
To take notes or search for course-related information	34 (6.6%)	56 (10.8%)	171 (32.9%)	186 (35.8%)	72 (13.9%)
To learn other courses	96 (18.5%)	119 (22.9%)	152 (29.3%)	106 (20.4%)	46 (8.9%)

Unsurprisingly, the motivations for non-study reasons were positively correlated with mobile phone dependence ($r_s = 0.37$, $p < 0.01$). In terms of study-related reasons, learning other courses was positively correlated with mobile phone dependence ($r_s = 0.171$, $p < 0.01$), while no significant correlation was observed between course-related activities and mobile phone dependence. Furthermore, students who were more prone to digital multitasking for non-study reasons were less receptive to any restrictions on phone use ($r_s = -0.217$, $p < 0.01$), indicating that they would be less likely to comply with such restrictions. In particular, habitual phone use was the most important factor in digital multitasking. Students with a higher level of phone-use habit were more likely to engage in digital multitasking for non-study reasons during class ($r_s = 0.302$, $p < 0.01$), and they were less willing to follow restrictions on phone use ($r_s = -0.112$, $p < 0.01$).

These findings suggested that (1) students with higher tendency to digital multitasking for non-study reasons and learning other courses would have a higher level of mobile phone dependence; (2) students preferring non-study digital multitasking would be less likely to accept any restrictions on phone use.

3.3. Beliefs about Reducing Phone Use

Intention to minimize phone use. Table 5 presents students' willingness to minimize their phone use during class. For the first item, "I should reduce the frequency . . . " (M = 4.28, SD = 1.27), 450 respondents (86.71%) acknowledged that they should reduce their phone use in class as much as possible. In terms of the item, "I think the school should introduce more . . . " (M = 3.91, SD = 1.30), 259 (49.90%) believed that they needed schools' further help to reduce their phone use, while 260 (50.10%) held the opposite view.

The result showed that the majority of the respondents would choose to reduce their digital multitasking intentionally. However, as for the other item, the results indicated a lack of consensus among the respondents, with almost half (49.90%) expressing agreement and the other half (50.10%) expressing disagreement. This even split distribution suggested that there was no clear dominant view of whether schools should introduce more restriction on phone use in class.

Receptivity to strategies for reducing digital multitasking. Figure 1 illustrates students' willingness to adopt specific strategies against their digital multitasking. For the moderate methods, 71.68% of respondents (372) reported being open to turning their phones into

silent or flight mode (M = 0.72, SD = 0.451), while 76.69% (398) were willing to put the phone somewhere unseen but within their reach (M = 0.77, SD = 0.423).

Table 5. Intention to minimize phone use.

	SD	D	PD	PA	A	SA
I should reduce the frequency . . .	16 (3.08%)	16 (3.08%)	37 (7.13%)	140 (26.97%)	204 (39.31%)	106 (20.42%)
I think the school should introduce more . . .	62 (11.95%)	84 (16.18%)	114 (21.97%)	145 (27.94%)	68 (13.1%)	46 (8.86%)

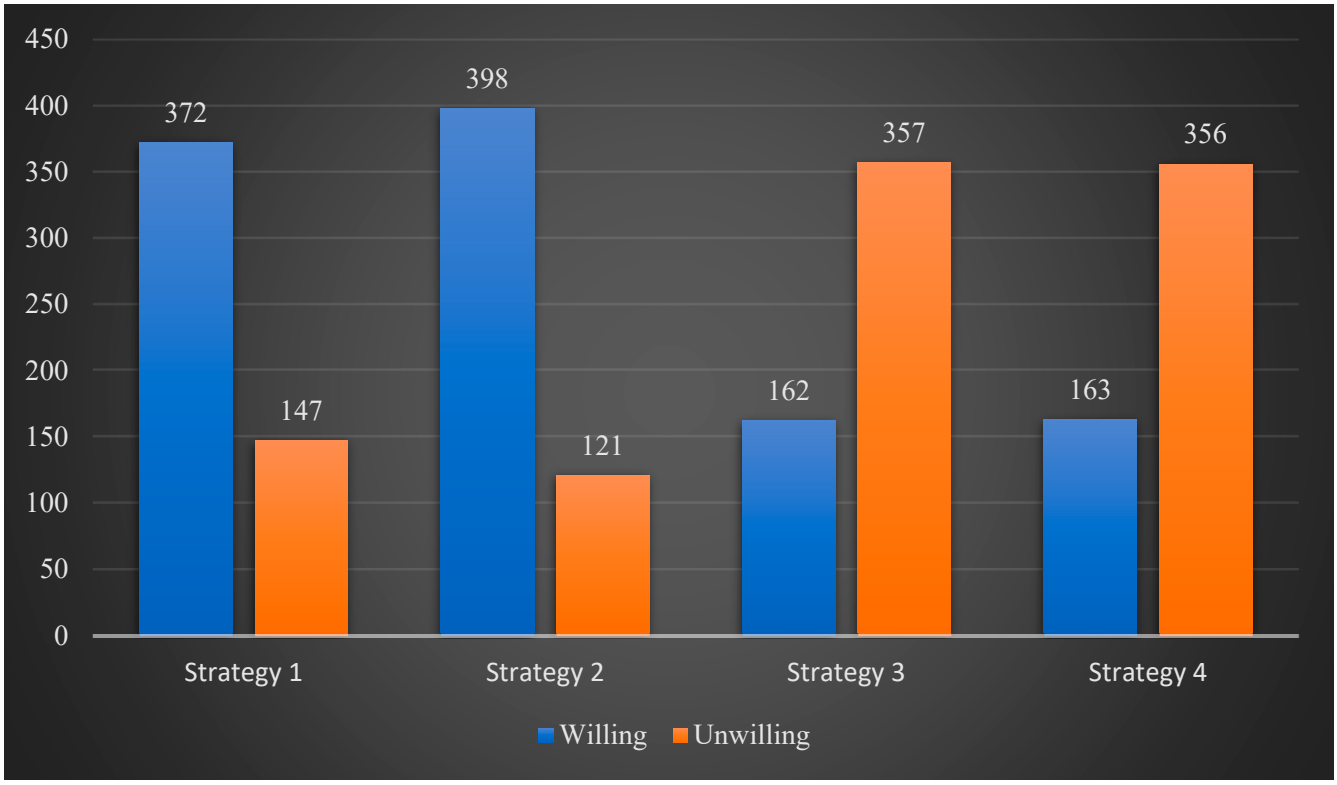

Figure 1. Receptivity to strategies for reducing digital multitasking.

Furthermore, students were generally reluctant toward restricted methods: only 31.21% (162) were willing to take no phone to class or put their phones someplace beyond the reach (M = 0.31, SD = 0.464), and 31.41% (163) were open to turning off their phones (M = 0.31, SD = 0.465). No significant correlation was found between such reluctance and other factors, such as age, gender, university rank, school's restrictions, and students' acceptance to their schools' restrictions. On the basis of some respondents' feedback, accessibility to their phones and immediate use during class were vital factors in determining their willingness to comply with restrictions.

Positive correlations were found among students' mobile phone dependence, frequency of phone use, frequency for other than course-related activities, and receptivity to strategies for reducing digital multitasking (see Table 6). Students with higher mobile phone dependence tended to engage in more digital multitasking during class, and they were less likely to accept restrictions on phone use, both moderate and restricted. Students who spent more time using their mobile phones were also less accepting of restrictions on phone use. Students with higher receptivity to moderate restrictions on phone use were more open to adopting restricted methods.

Table 6. Spearman's correlation matrix.

	1	2	3	4	5
1. Mobile phone dependence	-				
2. Frequency	0.330 **	-			
3. Frequency for other purposes	0.383 **	0.638 **	-		
4. Moderate method	−0.150 **	−0.138 **	−0.208 **	-	
5. Restricted method	−0.120 **	−0.219 **	−0.225 **	0.341 **	-

Note: ** $p < 0.01$.

4. Discussion

This exploratory descriptive study examined Chinese university students' magnitude of digital multitasking, motivation behind digital multitasking, and beliefs about reducing phone use. In this section, all the quantitative results of three measurements are analyzed and discussed separately.

4.1. The Magnitude of Students' Digital Multitasking

Currently, an increasing number of universities have recognized the negative impact of smartphone phone use in class, leading educators and policymakers to implement various methods to tackle this issue. In our study, we found that nearly half of the respondents (45.28%, 235) reported that their schools had implemented relevant regulations on phone use. However, during the analysis phase, we found no positive correlation between the implementation of school restrictions and the reduction in phone use frequency. Even in a phone-banned class, students continued to use their mobile phones, despite knowing it could be detrimental to their concentration to some degree, which is consistent with previous studies [29–31]. These findings highlight the need for more effective and sophisticated methods to reduce phone use and enhance students' learning outcomes from a Chinese perspective.

Regarding students' frequency of phone use, a significant number of respondents (82.74%, 278) reported using their phones often or very often (11–30 or over 30 times) in a typical school day. In contrast, only a small percentage (3.87%, 13) claimed that they never or rarely (1–3 times) used smartphones in a typical school day. This indicates that students used their smartphones much more frequently than in the previous study [2]. One possible explanation for this increase is that students starting college in the 2020s have had more exposure to digital devices.

4.2. Students' Motivation behind Digital Multitasking

In the present study, we found that, in testing students' mobile phone dependence, withdrawal was the most commonly endorsed, and interpersonal conflict was mostly opposed, presenting a similar trend to that in Walsh's work [28]. We also discovered that students' mobile phone dependence plays a crucial role in mediating different variables; those with higher levels of mobile phone dependence were more likely to use their phones in class, less likely to follow schools' rules on phone use, and more likely to engage in digital multitasking for non-study purpose. These results presented a similar trend with the previous studies [31,32] and provided further insights into the crucial role of students' mobile phone dependence in digital multitasking.

Meanwhile, we presented five possible motivations behind students' digital multitasking, with three being non-study- and two being study-related. We also illustrated frequencies of each motivation. Among all the factors, students' habitual phone use was the most influential in digital multitasking. Students with higher levels of phone use habit were more likely to engage in non-study-related digital multitasking in class. Although this study only presented a limited number of motivations, it can still shed light on the nature or correlation between students' motivations and their digital multitasking. Despite class-related purpose being reported as the most cited motivation, other purposes behind students' digital motivation could influence students' concentration and undermine their

learning efficiency. We found that students with higher levels of mobile phone dependence were more susceptible to non-study-related digital multitasking and were less likely to abide by school's rules on phone use. To improve learning efficiency, we believe that further investigation should be conducted on students' phone dependence and other factors that may prompt digital multitasking.

4.3. Students' Beliefs about Reducing Phone Use

In this study, we found that, while the majority (86.71%) respondents expressed an intention to reduce digital multitasking, they were mostly hesitant to follow the moderate or strict rules on phone use. Furthermore, no clear consensus was established (49.90% vs. 50.10%) regarding whether schools should impose more restrictions to promote phone use reduction. This gap may be explained by students increasing dependence on technological devices during their daily lives and academic pursuits as digital natives. These findings demonstrate that banning smartphone use in class may not be sufficient for addressing students' digital multitasking. Instead, appropriate regulations on phone use are urgently needed to strike a balance between the potential benefits and accompanying distractions of digital devices. These findings also highlight the importance for teachers and policymakers to consider more sustainable approaches to tackling this crucial challenge.

5. Conclusions

Currently, the prevalence of smartphones in higher education has resulted in heightened use among university students, leading to a concerning upsurge in students' digital multitasking. To minimize the impact of such behavior and, thus, promote sustainable higher education, further research into this field is warranted. This study employed a quantitative approach to examine Chinese university students' magnitude of digital multitasking, motivation behind digital multitasking, and beliefs about reducing phone use. The study found that (1) students' digital multitasking behavior was positively correlated with mobile phone dependence and their non-study motivation; (2) despite a number of participants acknowledging the phone restrictions in their schools, no discernible decrease in smartphone use was evident; (3) while the majority (86.71%) students expressed their intention to reduce digital multitasking, strict limitations on phone use were generally met with resistance by the students; (4) no clear consensus was established (49.90% vs. 50.10%) in regarding of whether schools should apply more restrictions to prompt a reduction in digital multitasking.

While the present study offers valuable insights into students' digital multitasking, it is important to acknowledge several limitations. (1) Due to the restrictions of students' confidentiality and online-based sampling method, more in-depth information about the participants, such as their academic performance, was not included as the variable in qualitative analysis. (2) Only a limited number of potential motivations were examined during the data collection phase of this study. (3) This study only employed a qualitative analysis approach to assess the nature of university students' digital multitasking behavior, which could probably limit the generalizability of the findings. (4) The sampling methods employed in this study may have introduced limitations to the findings. For example, convenience sampling may have caused a selection bias, as the students were recruited on the basis of accessibility rather than representing the entire group. Additionally, online-based snowball sampling may have resulted in a biased outcome, as students with specific interests were more likely to be selected in the study.

Therefore, to acquire a more holistic understanding of students' digital multitasking behavior, future research should consider (1) expanding the scope of variables examined in qualitative analysis, such as academic performance, precise durations of digital multitasking, and students' preference of task-switching, (2) incorporating more potential motivations in data collection procedure, (3) utilizing a mixed-method design that integrates both quantitative and qualitative approaches to obtain a more comprehensive understanding of this behavior among university students, and (4) employing more rigor-

ous sampling methods, such as random sampling and stratified sampling, to enhance the representativeness of the findings.

Author Contributions: Conceptualization, software, and writing—original draft preparation, Q.W.; writing—review and editing, X.W. and F.S.; supervision, Y.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Ministry of Education of China (grant number 2021100027) and China Association of Higher Education (grant number 21WYJYZD04).

Institutional Review Board Statement: Not applicable.

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

Data Availability Statement: The data presented in this study can be made available upon reasonable request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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A Study on Technology Use for Sustainable Graduate Education Internationalization at Home: Chinese Teachers' Experiences and Perspectives

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Abstract: Diverse innovative strategies for achieving sustainable internationalization have emerged as a consequence of the continuing development of education and technology. Several academic institutions in China have made the pursuit of international recognition a central policy objective in an effort to achieve global prominence in the coming decades. This study aimed to explore the use of technology in promoting the sustainable internationalization of graduate education in China using teachers' experiences and perspectives. In this regard, an assessment was conducted of the teachers' experiences and perspectives on the aspects involved in the use of technology-based education for sustainable internationalization as well as the effect of these aspects on the internationalization of graduate education. The sample consisted of 806 teachers from different universities in China. A questionnaire was used to collect the data. The data analysis was carried out using SPSS 22, JASP and SmartPLS 4. The results showed that Chinese teachers had satisfactory experiences regarding the use of technology in internationalizing graduate education. Furthermore, teachers were highly satisfied with using technology to support collaborative online international learning, research cooperation, intercultural competence development and virtual mobility. The results also revealed that teachers were less likely to be satisfied with using technology to support open exchange programs and the internationalization of the curriculum. In addition, the results demonstrated that collaborative online international learning, research cooperation and intercultural competence development had a direct effect on the internationalization of graduate education. Based on the findings, it was concluded that the situation regarding graduate education in China is acceptable, while at the same time, support and more effort from the government and teachers are required.

Keywords: experience; graduate education; perspectives; sustainable internationalization; technology

Citation: Xu, Q.; Boudouaia, A. A Study on Technology Use for Sustainable Graduate Education Internationalization at Home: Chinese Teachers' Experiences and Perspectives. *Sustainability* **2023**, *15*, 10621. https://doi.org/10.3390/su151310621

Academic Editors: Rustam Shadiev, Barry Lee Reynolds and Rui Li

Received: 9 June 2023
Revised: 3 July 2023
Accepted: 4 July 2023
Published: 5 July 2023

1. Introduction

The sustainable internationalization of graduate education has been the focus of many universities around the world, especially in China. China is among the largest economies in the world [1,2]. Hence, investment in the lifelong internationalization of graduate education is necessary for China to improve and sustain scientific investigations and instruction cooperation. Academic institutions that actively engage in internationalization are more inclined to implement the requisite pedagogical and didactical modifications to adapt to the evolving nature of content delivery and learning tools [1,3]. The continuous progress of society and education has supported domestic internationalization [3]. For instance, the collaboration that has been supported by society and education has led to the development of interactive and collaborative learning and the intercultural competence that teachers and parents encourage students to acquire has resulted in the establishment of open virtual mobility [1,3]. The establishment of a completely internationalized domestic economy necessitates not only a contemporary pedagogical methodology but also an all-encompassing educational setting for every student [1–3]. According to Robson et al.

(2018) [3], the emergence of digital learning provides a platform for students to interact with instructors and classmates from diverse cultures, thereby enhancing and promoting their "global mindsets". In 2018, the Chinese government released data indicating that 9.4 million students participated in a college entrance exam in China during the year 2017. Nonetheless, the total number of Chinese students enrolled in foreign educational institutions amounted to 608,400, which accounts for a mere 6% of the overall student populace. To clarify, due to the increased interconnectivity of the global economy, a majority of students have chosen to pursue their higher education at a domestic university, instead of registering as an "international" student. Under such conditions, the opportunities for students to cultivate their advanced cognitive and intercultural abilities are severely restricted. In this respect, officials in China's government are eager to strengthen the steps that have already been put in place to boost the diversity of the country's academic institutions [4]. Internationalization has become a strategic policy priority for many Chinese universities that are aspiring to become world-class in the upcoming decades [5].

There are a number of federal programs that offer financial assistance in the form of grants to colleges that are attempting to broaden their international presence [4–6]. The government "places a high premium on subversive technological developments" and "encourages Chinese research organizations to undertake cutting-edge research", according to the Communist Party of China's (CPC) Five-Year Plan. Government officials have also stated that they intend to "implement the Internet+ Action Plan in order to establish application technologies for the Internet of Things" [7]. One particularly intriguing proposal is to provide universities and research institutes with the opportunity to become innovation leaders, with expanded decision-making control over research spending and globalizing the universities for an extended period of time. The Internet of Things (Internet+) already has a significant impact on the internationalization of graduate education in China and around the world and this trend is expected to increase over time [7,8]. The development of new technologies has allowed for the rise of online universities like the Open University, which provide courses at a distance [9]. Technology may guarantee that all students have equal access to internationalization possibilities [10]. The world's universities have experienced a transition from isolation to interdependence and from connectivity to hyperconnectivity. In this regard, the use of technology enables the sustainable internationalization of graduate education. This issue requires the attention of academics and researchers. However, as evidenced by the examination of existing research, little is known about teachers' perspectives on the use of technology for the sustainable internationalization of graduate education in China [4,9]. This study set out to fill that void, aiming to better understand teachers' experiences and perspectives on using technology in the sustainable internationalization of graduate education in China, the aspects that are supported by technology as part of the internationalization of graduate education in China and which aspects have a direct effect on the internationalization of graduate education. In this regard, this study aims to investigate teachers' experiences and perspectives on using technology in the sustainable internationalization of graduate education in China, identify which aspects are supported by technology as part of the internationalization of graduate education in China and determine the aspects that affect the internationalization of graduate education. The objective of this study was to enhance the sustainable internationalization of graduate education by providing guidance to policymakers on the allocation of resources to facilitate technology adoption. The study aimed to support informed decision-making for the promotion of sustainable internationalization in graduate education. This research has the potential to assist policymakers and educators in other countries in enhancing the degree of internationalization within their institutions. China, a highly developed nation, can serve as a model and exemplar for achieving this objective. Emulating a highly developed nation can aid other countries in identifying their deficiencies, vulnerabilities and necessities, while also facilitating their replication. Moreover, the current investigation has the potential to offer innovative research on the pressing issue of the sustainability and globalization of education, which hold substantial importance for educators, institutions of higher learn-

ing and governmental bodies worldwide. The current study's findings have contributed to the comprehension of educators' perspectives on the utilization of technology to promote sustainable internationalization in postgraduate education. The aforementioned has far-reaching ramifications for the field of education.

The present research paper comprises various sections aimed at providing a comprehensive elucidation of the study. The document comprises various sections, namely an introduction, literature review, present study, methodology, results, discussion, conclusion, implications and limitations and future research directions. In order to enhance the clarity of the presentation of the ideas and content, certain sections such as the literature review and methodology were subdivided into smaller sections.

2. Literature Review

2.1. Internationalization at Home

Knight (2006) [11] distinguished internationalization at home as one of two interdependent, rather than independent, internationalization streams in his subsequent treatment of key concepts, elements and justifications. He claimed that all worldwide educational initiatives, courses and projects, as well as the movement of students, instructors, scholars, programs and curricula across borders, fall under the umbrella term of "Internationalization Abroad". On the other hand, "internationalization at home" refers to initiatives that help students gain intercultural skills and a global perspective. Internationalization at home does not necessitate the enrollment of students from other countries, despite the fact that doing so may be advantageous [1,2,11]. Internationalization at home (IaH) may be viewed as a somewhat limited idea, which refers to the introduction of an international and intercultural dimension into the curriculum studied in a local setting, whether it is a formal or an informal curriculum [10]. In this regard, internationalization at home is about the combination of international content with the national curriculum content in the local environment, which aims to prepare students for performance in an international and multicultural setting [10,12,13]. Internationalization at home is neither an end in and of itself nor a pedagogical concept, but rather a set of "at-home" resources and activities with the goal of developing students' international and intercultural competencies [13]. It is important to note that IaH, like internationalizing the curriculum as a whole, is context- and discipline-specific [14].

2.2. Internationalization at Home and Technology

The expansion of "internationalization at home" opportunities has been greatly facilitated by the widespread use of social media platforms and flexible educational technology [15]. Mittelmeier et al. (2019) [16] showed the support that technology provides for the internationalization of higher education at home. They revealed that students are able to study "through institutions established in a culture or country distant from their own, while remaining in their own country", [16] and they perceived this as a third kind of internationalization that is made possible by distance learning in all of its manifestations because currently, many students use technology for learning. In this way, it is also knowledge, teaching and learning that have become mobile due to the availability of technology, and time and distance are more easily navigated [16,17]. The internationalization of a Chinese university from the students' perspectives was studied by Guo et al. (2022) [5]. The research found that students saw internationalization via a Westernization lens, raised concerns about uneven access to internationalization and questioned the use of English in the university's official and informal internationalization initiatives [5]. Deardorff et al. (2012) [18] revealed that recent advancements in the internationalization of higher education in one region seem to be widely and rapidly available in almost any other location with Internet access. There are now more opportunities for domestic internationalization thanks to the exponential growth of technology. Therefore, students from all over the world may now more easily network with their counterparts in classrooms and universities situated in faraway nations [7–9]. With the help of modern technological advancements,

it is possible now for universities, teachers and students to work together and engage in mutually beneficial learning with peers from all over the globe [16,19], expanding their horizons and enriching their understanding of and appreciation for different cultures.

The literature has advocated some dimensions and aspects of internationalization at home. However, Knight (2006) [11] considered the international/intercultural dimension of the curriculum along with research cooperation and local and foreign language studies (liaison with local cultural/ethnic groups) as factors of internationalization at home. The international/intercultural dimension of the curriculum undervalues the importance of the curriculum in the endeavor of internationalization at home, since it is not an "associated aspect" nor an "activity" but is at the core of the idea [11]. The use of technology has allowed for a plethora of programs that include curricula tailored to the improvement of skills and knowledge, including foreign language skills [11,20], and boosting the implementation of joint or double degrees [11,16,18]. Thanks to technological advances in the field of pedagogy, educational interventions designed to assist students in acquiring skills and knowledge can now be broadly disseminated via a unified curriculum [11,19]. Still, technology has made it simpler for multicultural teams to collaborate, increasing the likelihood that they will be able to evaluate and enhance educational programs and courses as a whole [7,9,11,20]. The Organization for Economic Co-operation and Development states "A curriculum with an international orientation in content and/or form, aimed at preparing students for performing (professionally/socially) in an international and multicultural context and designed for domestic and/or foreign students" [20]. The internationalization of the curriculum aims for "the incorporation of international, intercultural and/or global dimensions into the content of the curriculum as well as the learning outcomes, assessment tasks, teaching methods and support services of a program of study" [21]. Educators all across the world may work together more efficiently using digital tools to identify and address any problems that may arise for students as they go through the curriculum [7,20,21]. Moreover, teachers and students may connect with each other and with program material from across the world using social media [19,20].

The integration of technology into the field of education holds promise for improving communication and enabling a more inclusive and cost-effective online learning environment that can cater to a broader student population, rather than being restricted to a select few with privileged access [17,22]. Collaborative online international learning is another dimension of internationalization at home and is an educational strategy that has the potential to augment the acquisition of a wider range of skills while affording students the chance to engage with peers from various parts of the world [22]. The effects of collaborative online international learning on students' cross-cultural communications were investigated by Pouromid (2019) [23], comparing institutions in Japan and Taiwan. The data are utilized to shed light on the under-researched potentials of collaborative online international learning in internationalizing English-as-a-foreign-language classrooms and providing students with cross-cultural communication opportunities in a virtual and multilingual setting. Students who felt their English skills were insufficient employed a wide range of multimodal strategies to continue interacting with classmates from diverse cultural backgrounds. Therefore, as part of the process of internationalizing higher education, Collaborative Online International Learning was found to be effective in facilitating communication between students in the two countries. Here, it can be estimated that the integration of technology facilitates the opportunity for both students and teachers to actively participate in global communication and collaboration with fellow peers through various online platforms [17,19,22]. This may lead to enhancing their sense of ownership over their academic pursuits and ability to initiate and produce innovative ideas during the various stages of research, interpretation, dissemination and adjustment [19,20]. The case study by Wihlborg et al. (2018) [19] elucidated the practical application of collaborative and transformative learning in the context of "internationalization at home". The research was conducted by utilizing a cocreated initiative that implemented a digital global partnership between educators and learners through the utilization of a course administration platform

(MOODLE) and unrestricted technological resources (Adobe CONNECT). The study was conducted with the participation of two research universities located in Sweden and the United States. Ninety nursing students from each university per semester were involved in the study over multiple semesters. The findings indicate that potential solutions were generated to address the obstacles and devise tactics for a forthcoming tertiary education framework that fosters global communication. The integration of technology enables the implementation of collaborative learning strategies, aiming to cultivate a collective sense of accountability among students from different countries, thereby shifting the responsibility of learning onto the students themselves [17,19,20]. Virtual international exchanges provide novel opportunities for cross-cultural communication and learning across different countries and societies. Garcia et al. (2023) [24] analyzed a case illustration of two partner institutions and a business faculty who employed a collaborative online international learning experience amid the peak of the COVID-19 pandemic and shift to online learning. The aim was to globalize an undergraduate business class and leverage pre-existing technology to provide a case study project that would enhance students' global mindsets. The study analyzed qualitative feedback obtained from students enrolled in an international business course, originating from both an American college and a Peruvian university, to identify significant themes related to a virtual-collaborative-online-international-learning-based learning experience. The efficacy of the learning experience and the benefits of collaborating with peers and faculty in a virtual environment were confirmed by the feedback provided by the students in both nations' end-of-course evaluations.

Woicolesco et al. (2022) [25] considered academic mobility and collaborative online international learning as some of the "internationalization at home" dimensions at Brazilian institutions. Virtual mobility has been emphasized in the literature as an important element of the "internationalization at home" aspect. Rajagopal et al. (2020) [26] explored the learners' skills and knowledge that underpin open virtual mobility (OpenVM)—a recent development in online education that brings together these two concepts. The results showed that a group concept mapping study, which included contributions from experts in both virtual mobility and open education, identified the following contributing factors: intercultural skills and attitudes; networked learning; active self-regulated learner skills; media and digital literacy; autonomy-driven learning; interactive and collaborative learning in an authentic international environment; and open-mindedness. Similarly, Tereseviciene et al. (2013) [27] studied how virtual mobility might assist the internationalization of higher education. Results have shown that virtual mobility contributes positively to intercultural understanding, language learning and the globalization of higher education. In addition, virtual internationalization efforts at Ukraine's Sumy National Agricultural University (SNAU) were evaluated by Kobzhev et al. (2020) [28]. The results indicate that the Sumy National Agricultural University is emphasizing the use of digital tools in its global activities and that its involvement in virtual international programs has enhanced academic mobility, guaranteed international standards for the quality of educational services and provided students with opportunities to gain international experience in the area of agrobusiness and research. In this regard, it can be said that technology has made virtual mobility a more environmentally sustainable alternative and suitable for students [4,16,17]. This relevance may be apparent in the facilitating of collaboration between students across borders through online means [19,22], thereby enhancing the dissemination of knowledge and hence enabling them to reach various platforms available at other academic institutions [20,21,28].

The role of online exchange programs was highlighted by researchers as a dimension of internationalization at home. The advent of technology has facilitated the rapid exchange of programs, in which a collaboration of groups of program designers was facilitated in order to ascertain the specific requirements of each university's curriculum. The effects of online exchange programs on the growth in students' intercultural competency were studied by Zilberberg Oviedo and Krimphove (2022) [29]. The study's most noteworthy conclusion is that Brazilian international office managers see virtual exchanges as a key com-

ponent of internationalization at home and, by extension, a means toward a more equitable internationalization framework. The negative aspects of virtual exchanges include major technical issues, low levels of language proficiency among faculty and students, a lack of commitment and the disadvantages arising from a lack of deeper and more intense cultural immersion when compared to real-world experiences; however, there is still general agreement that they help students develop intercultural competence. In a qualitative research study, Ganassin et al. (2021) [1] looked at how 15 educators and school leaders see the role of virtual exchange (VE) within their institution's "internationalization at home" aspects. The participants expressed that virtual exchange has the potential to enhance globalization by giving more people the opportunity to participate in international and multicultural encounters. The internationalization and global participation of Chinese universities might benefit from VE (HEIs). Nevertheless, effective preparations and strategies are necessary to address the challenges of its application. Among them are the unique power dynamics among different types of students and the technological and political barriers they face. Technology facilitated the organization of seminars among teachers to critically analyze program deficiencies and replicate them through the exchange of experiences.

In addition, research cooperation that is supported by technology has a significant role. When researchers from various nations work together, they establish international research teams [30,31]. Teachers and students from all around the world may work together on research projects thanks to technological advancements, opening the door to potential collaborations that will benefit all parties involved as well as solutions to pressing global issues [30,31]. For instance, teachers and students may now attend international conferences all around the world thanks to technological advancements that allow them to network with professionals from other fields [31,32]. These groups conduct studies and share their results to advance scholarship and promote useful reforms in practice [31,32]. Teachers' use of digital tools for research and sharing findings boosts the quality of academic inquiry and lays the path for more tangible changes to be put into practice. Hence, research fields have potentially increased the impact and greater significance of this via doing thorough cross-national studies [31–33]. Research that spans national boundaries can more easily be applied to a wide range of people and cultures [30,31]. Additionally, participating in international collaborative research provides opportunities to develop win–win partnerships and address global issues in education [30,31]. The internationalization of education, the platform through which joint efforts yield greater results than those of their component parts, is one of the primary reasons why collaborations in research are so crucial [4,30,34]. It is possible that breakthroughs in problem-solving and new ideas will emerge from the interactions between scientists and individuals from other nationalities and cultures [1,4,35]. In other words, online conversations between people from different cultures and backgrounds can spark the development of novel perspectives and methods for approaching problems [4,35].

Furthermore, intercultural competence is often defined as "the ability to communicate effectively and appropriately in intercultural situations" [36]. Safipour et al. (2017) [37] note that teachers working in a global context may need to help their pupils adjust to both new academic and cultural challenges. Ultimately, internationalization at schools aims to provide students with the intercultural competence they will need to thrive in today's increasingly heterogeneous workplace [38,39]. Intercultural competence is increasingly recognized as a source of competitive advantage as schools that teach their students to work effectively across cultural boundaries produce more employable graduates [40,41]. The "integration of culture" in the classroom refers to incorporating international and intercultural perspectives into course content and the teaching–learning process [42–44]. One possible approach is for participants in groups to adopt a more international outlook. Furthermore, some teachers might not feel ready for, or at ease with, this duty [45]. Teachers often complain about the time commitment of their job because they are passionate about their subjects [4,46]. Although lectures, group work and projects have always been part of programs, recent developments in information and communication technology have

opened up exciting new possibilities for implementing these strategies on a global scale [4]. The utilization of technology has extended the scope of what is now possible in terms of transnational and intercultural education and this is why students felt the need to adopt technology to ameliorate the level of their intercultural competence [4,43,45]. In addition, one advantage of using technology is that students may engage in academic endeavors without having to be sidetracked by cultural differences, i.e., technology has promoted worldwide collaboration among students [9,36,42] and made it possible for them to break up cultural differences, be proficient in interactions and conduct themselves in intercultural circumstances [41,45,46]. Still, the incorporation of technology allows students to easily pursue and involve multiple elements and activities, including the incorporation of information from various cultures [42,46]. Technology has allowed students from all over the world to work together without having to take a break from their studies [9]. The incorporation of a global perspective into virtual teams provides a useful setting for the cultivation of intercultural communication and competence, both of which are crucial in modern education [36,40,41]. The prevalence of virtual teams reflects the way students operate presently [9].

3. The Present Study

The current study aimed to investigate teachers' experiences and perspectives on using technology in the sustainable internationalization of graduate education in China, identify which aspects are supported by technology as part of the internationalization of graduate education in China and determine the aspects that affect the internationalization of graduate education. China was selected for this study as it presents one of the best models for the internationalization of education in the world. The success that China has attained in internationalizing its universities is reflected in its success in attracting foreign professors, teachers and students from many countries. In addition, the collaboration between Chinese universities and international universities is demonstrated by the instigation of online events and conferences, the exchange of programs and the exchange of teachers and students before, during and after the COVID-19 pandemic, despite the difficult situations and scenarios that the world endured. This study focused on collecting the experiences and perspectives of teachers from Chinese universities in Wuhan, without referring to the perspectives of international universities about the local context in China and in the city from which COVID-19 emerged. Based on a review of previous studies, the following research questions were developed to guide the study:

A. How do teachers perceive their experiences of using technology in supporting sustainable internationalization of graduate education in China?
B. What aspects do teachers find more supported by technology to achieve sustainable internationalization of graduate education in China?
C. What aspects affect the internationalization of graduate education?

4. Methods

4.1. Research Design

This research focuses on the use of technology for the sustainable internationalization of graduate education in China, which the researcher refers to as "home". The methodological approach used in this study is quantitative. This is exploratory research, which is described as investigating an issue that has not been well clarified, has been under-investigated or is otherwise poorly understood. Exploratory research was used because it facilitates the collection of data from a large number of participants, which in turn makes it possible to conduct an in-depth investigation into teachers' experiences and perspectives on using technology for the sustainable internationalization of graduate education at home, in China. A questionnaire was used to collect data from participants.

4.2. Participants

The participants are teachers with expertise and a high level of familiarity regarding the present state of internationalization in graduate education within China. Therefore, their responses carry greater significance than would those of students and they have made valuable contributions to this research. The final sample of participants comprised 806 teachers from different universities in Wuhan, Hubei province, China, during the 2022–2023 academic year. The choice of Wuhan as the research site was based on the researcher's objective to identify the features of graduate education in one of China's most significant cities. As shown in Table 1, of the 806 teachers, 341 were male and 465 were female; 409 were assistant professors, 203 were associate professors and 194 were full professors. The ages of the teachers were categorized as follows: 385 teachers were between 29 and 34 years old, 137 teachers were between 35 and 40 years old, 77 teachers were between 41 and 45 years old and 207 teachers were 46 or older, making a total of five categories.

Table 1. Participants' profiles.

Demographic Variables	Frequency	Percentage	M
Gender	806	100	
Male	341	41.50	1.58
Female	465	56.6	
Level	806	100	
Assistant professor	409	49.80	1.73
Associate professor	203	24.70	
Professor	194	23.60	
Age	806	100	
29–34	385	46.80	
35–40	137	16.70	2.13
41–45	77	9.4	
46 and older	207	25.2	

4.3. The Research Instrument

The questionnaire used in the current study consisted of three main sections (Appendix A). The first section collected participants' demographic data. The second section inquired into teachers' experiences of using technology for the internationalization of graduate education based on the user experience scale developed by Schrepp and Thomaschewski [47], encompassing six scales with twenty-six items that aim to get quick and immediate measurements of the user experience. The six scales are: attractiveness, efficiency, perspicuity, dependability, stimulation and novelty. The third section collected data about participants' perspectives regarding the use of technology in internationalizing graduate education in seven different areas or dimensions. These seven dimensions, incorporated according to the results of previous studies that investigated the virtual internationalization of education, included: online exchange programs; virtual mobility; collaborative online international learning; internationalization of curriculum; research cooperation; intercultural competence development; and internationalization of graduate education [1,5,6,16,18,19,21,36,39,43]. This third section utilized a five-point Likert scale (strongly disagree; disagree; neutral; agree; and strongly agree) asking teachers to rate their agreement with statements within the different dimensions. The study also included items from the literature on internationalization at home [1,2,5,6,16,18,21,30,31,33,36,39,42–44] and, initially, utilized 37 different items for improving the efficacy of the research tool. Thereafter, a group of seven educators and specialists verified the face validity of the study instrument. Several items were improved, replaced and altered after the panel's recommendations were implemented and two were taken out entirely. Some examples of these additions and adjustments are the following: "capability to diagnose learning competencies using specific applications (use applications to accurately diagnose learning competencies as part of evaluation and assess-

ment)"; "capability to transition from a local program's content to a non-local program's content using social media and videos (use technology to bridge the gap between local and non-local program content)". This questionnaire was developed in Chinese considering that the participants' native language is Chinese. Thereafter, a pilot test was conducted to verify the basic psychometric properties of the instrument and the panel's opinions (validity and reliability). Cronbach's Alpha = 0.818, as noted by AL-Qadri et al. (2023) [48], suggests that the reliability and validity values are above average. At its peak, the questionnaire had sixty items. All of the required permissions were obtained from the participating professors and their participation was entirely voluntary.

The study's validity and reliability were evaluated after the questionnaire had been sent to participants and data had been collected. In addition, the factorial validity of the study instrument was examined. This research yielded a higher KMO value (0.955) than has been previously reported in the literature [49,50]. Data with multiple variables were normally distributed, as shown by the significance of the Chi-square statistics obtained at the end of the BST. There is conclusive evidence that the BST is significant (X_2 = 33476.905, df = 703, $p < 0.001$). As the KMO value is more than 0.60, these findings confirmed the instrument's suitability for factor analysis [48–50]. With this data set, six variables seem to be the most likely choice. The first exploratory factor analysis (EFA) using Eigenvalues for items found a thirteen-factor structure. Thirteen factors were identified by the analysis and factor loads ranged between 0.90 and 0.52. The values of the items' communalities varied from 0.54 to 0.96. All items in the study instrument had loading values of more than 0.50 and all factor loading were statistically significant at $p < 0.01$ [49,50].

To emphasize the validity of the measured questionnaire, the CFA was accomplished to evaluate the measurement model while retaining the same factor and items. The measurement model was assessed using multiple fit indices, including the Chi-square value (4043.672; $p < 0.001$), the root mean square error of approximation (RMSEA) = 0.073, the comparative fit index (CFI) = 0.920, the goodness of fit index (GFI) = 0.924, the Tucker–Lewis index (TLI) = 0.913 and the standardized root mean square residual (SRMR) = 0.047. The guidelines for evaluating the adequacy of fit are as follows: CFI and TLI values equal to or greater than 0.90; RMSEA values with the upper bound at or less than 0.08; and SRMR values equal to or less than 0.06. All fitted indices' values were appropriate for using these instrument factor models for measuring the study aspects [48,49]. The Cronbach's Alpha for the individual subscales of the instrument was between 0.40 and 0.86. In this respect, the research instrument had sufficient validity to warrant deployment [48–50].

4.4. Data Collection Procedures

The researchers were aware of the importance of resolving the questionnaire's validity and reliability to ensure accurate and reliable results. Norms of ethics in data collection are essential for achieving this objective [51,52]. In light of this, sanction from the College of Humanities Research Ethics Committee at the Wuhan University of Engineering Science was obtained to collect data for research purposes. Teachers from a number of universities in Wuhan, China, were selected using the purposive sampling strategy. During a purposive sample, units are selected based on essential and pertinent criteria determined to be essential to the research. Throughout the selection procedure, teachers' track records of employing technology to internationalize education for more than three years were considered. Teachers with more than a few years of experience were sought out specifically for inclusion in the study; therefore, professors with three years of experience were the appropriate benchmark. The researchers initiated their search for teachers with at least three years of experience in their respective disciplines by contacting the faculty deans and department chairs, which disclosed that many teachers were recruited recently, i.e., they are novices in their schools. Some faculty leaders and department heads required anonymity to prevent teachers from expressing misleading ideas or opinions. The researchers explained the study and assured the participants that their institutions' names, faculty names and teacher names would remain confidential. The researchers presented the study to the

department chiefs and faculty members. The majority of teachers were contacted personally in their offices by the researchers or the department chiefs. In addition, the researchers sought the help of other teachers to distribute the questionnaire among their colleagues who had more than three years of teaching experience. The researchers explained the study to the teachers and reassured them that their information would be kept private. Participant consent entailed signing a paper consent form. The current study included 806 instructors from numerous universities in Wuhan, China. The questionnaire was distributed to 806 teachers. Some teachers responded immediately, while others required several days. Even after gathering all the questionnaires, many questions remained unanswered. Therefore, only complete questionnaires were included in the results and this provided the total of the 806 teachers in the present study.

4.5. Data Analysis

Statistical Product and Service Solutions (SPSS) Software (Version 22.0), JASP and SmartPLS 4 were used for data input. After receiving the questionnaire sheets from the participants, the researcher coded the data manually and inserted each participant's answers into SPSS software using numbers. For example, the Likert scale was coded as follows: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree. The age of participants was coded as follows: 1 = 29–34 years old; 2 = 35–40 years old; 3 = 41–45 years old; and 4 = 46 years old and older. Although data input was one of the most important steps in this research, special care was taken to ensure accurate findings. Finally, the analysis and interpretation of the results were performed. Subsequently, an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) were conducted using both SPSS 22 and JASP, whereas the relationship between variables was tested using SmartPLS 4. In addition, teachers' experiences and perspectives were analyzed using SPSS 22.

5. Results

Teachers' experiences of using technology to help internationalize graduate education were examined. The results show that the use of technology in internationalizing graduate education received a positive evaluation from teachers, with scores between excellent and good, according to the benchmark data set. As shown in Table 2, attractiveness, efficiency and dependability belonged to the excellent category. This means that using technology for internationalizing graduate education is attractive, enjoyable, friendly, pleasant and helped in performing tasks quickly and efficiently. In addition, the participants' interaction with technology is predictable, secure and meets their expectations. However, stimulation, novelty and perspicuity were classified as good. This implied that teachers are satisfied with using technology in internationalizing graduate education.

Table 2. The questionnaire results of teachers' experiences of using technology for the sustainable internationalization of graduate education.

Aspects	Average Score	Compared to Benchmark
Attractiveness	3.20	Excellent
Perspicuity	1.81	Good
Efficiency	3.11	Excellent
Dependability	3.09	Excellent
Stimulation	1.79	Good
Novelty	1.61	Good

Table 3 shows the descriptive statistics of the level of each of the six dimensions related to "internationalization at home" using technology. The analyses revealed that using collaborative online international learning is the most dominant aspect (M = 4.705). The results also indicate that research cooperation (M = 4.019), intercultural competence development (M = 4.007) and virtual mobility (M = 4.001) are also frequently used aspects.

However, the results demonstrate that the use of technology to support online exchange programs (M = 2.112) and the internationalization of the curriculum (M = 2.012) are less frequent.

Table 3. Aspects supported by technology for the "internationalization at home" of graduate education.

Dimensions	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean
Online exchange programs	15	21	6	30	28	2.112
Virtual mobility	21	27	1	22	29	4.001
Collaborative online international learning	3.3	4	9.1	46.2	34.7	4.705
Internationalization of curriculum	22	34	0	27	17	2.012
Research cooperation	17	24	9	28	22	4.019
Intercultural competence development	25.2	35	1.8	23.1	14.9	4.007

Structural Model

The data were analyzed using the partial least squares structural equation modeling (PLS-SEM) technique with the aid of the Smart PLS 4.0 software package, as described by Ringle et al. (2005) [53]. The model's goodness was assessed using various fit indices, as recommended by Hair (2014) [54]. The results indicated that the model was of good quality, with an SRMR of 0.264, d_ULS of 48.951, d_G of 3.148, Chi-Square (x2) of 12,272.147 and NFI of 0.633. These findings provided confirmation of the validation of the measurement model. Table 4 presents the results pertaining to the construct validity, discriminant validity and reliability. The adequacy of all values was confirmed, indicating the quality of the model [55].

Table 4. The construct validity, discriminant validity and reliability of the structural model.

Variables	α	rho_A	CR	AVE	Discriminant Validity					
					1	2	3	4	5	6
Collaborative online international learning	0.936	0.993	0.943	0.734						
Intercultural competence Development	0.691	0.949	0.938	0.722	0.135					
Internationalization of curriculum	0.942	0.961	0.952	0.739	0.923	0.139				
Internationalization of graduate education	0.554	0.928	0.765	0.621	0.124	0.941	0.187			
Online exchange programs	0.834	0.452	0.243	0.296	0.732	0.138	0.708	0.238		
Research cooperation	0.756	0.874	0.836	0.553	0.632	0.215	0.648	0.393	0.888	
Virtual mobility	0.878	0.571	0.799	0.523	0.862	0.126	0.812	0.207	0.969	0.711

Note: α = Cronbach's Alpha, CR = composite reliability, AVE = average variance extracted.

The hypotheses were tested. Direct path significance was measured and standard errors were estimated using the Bootstrap resampling approach with 5000 resamples [53]. Table 5 and Figure 1 illustrate the findings. It was found that there was not a significant positive and direct effect of online exchange programs on the internationalization of graduate education (β = −0. 072, t = 1.000, p = 0.318) and so H1 had not been accepted. Virtual mobility did not have a direct significant effect on the internationalization of graduate education (β = 0.087, t = 1.617, p = 0.106) and so H2 had not been accepted. Collaborative online international learning had a direct effect on the internationalization of graduate education (β = 0.114, t = 2.135, p = 0.033) and so H3 had been accepted. Internationalization of curriculum did not have a direct effect on the internationalization of graduate education (β = 0.045, t = 0.954, p = 0.340) and hence H4 had not been accepted. Research cooperation had a direct effect on the internationalization of graduate education (β = 0.090, t = 2.053, p = 0.04), so H5 had been accepted. Furthermore, intercultural competence development had a direct effect on the internationalization of graduate education (β = 0.759, t = 23.138, p = 0.00) and so H6 had been accepted.

Table 5. The hypotheses results.

Hypotheses	β	M	SD	T Values	*p* Values
OEP → INGE	−0.072	−0.021	0.072	1.000	0.318
VM → INGE	0.087	0.073	0.054	1.617	0.106
COIL → INGE	0.114	0.098	0.053	2.135	0.033
INC → INGE	0.045	0.041	0.047	0.954	0.340
RC → INGE	0.090	0.095	0.044	2.053	0.040
ICD → INGE	0.759	0.758	0.033	23.138	0.000

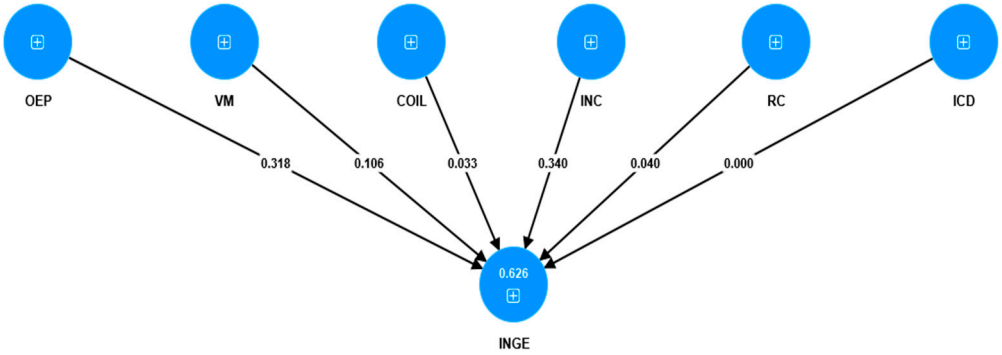

Figure 1. The research model results.

6. Discussion

Concerning the first research question, which pertains to the experiences of teachers in utilizing technology to facilitate the internationalization of graduate-level education, the results of the present study reveal that Chinese teachers have a satisfactory experience regarding the use of technology in internationalizing graduate education. The excellent category for attractiveness, efficiency and dependability, as well as the good category for stimulation, novelty and perspicuity, demonstrated that teachers have a strong belief in the role that technology plays in facilitating the internationalization of graduate education. This is due to the fact that teachers perceive technology as highly efficacious, capable of capturing students' focus and engagement, while concurrently enhancing their academic performance. According to teachers, the utilization of technology facilitated students' access to diverse global platforms and websites, hastened their learning process through collaboration with international peers and provided them with enjoyable opportunities to apply their knowledge alongside others. Technology facilitated the opportunity for students to engage in the exploration of novel subject matters and enhanced their comprehension of intricate concepts through cooperative efforts with diverse teachers and peers across the globe. In addition to teachers' ability to actively involve students during instructional sessions, students can also engage in cross-cultural communication with peers from various international universities. By means of web-based instructional sessions and educational activities, students collaborate in order to resolve academic challenges. Collaborative activities provide a platform for students to exchange their thoughts and ideas while extending support to one another. Simultaneously, technology facilitates individualized engagement between educators and their colleagues overseas. Students have the opportunity to inquire about topics pertaining to the classroom and obtain supplementary assistance on complex subject matters. Teachers possess specialized knowledge and express contentment with technological tools, as they have found them to be more straightforward and efficient in facilitating the sustainable global expansion of graduate instruction. These results are consistent with the study of Malcolm and Roll (2016) [15], who found that students were satisfied with using assistive technology as they found it supportive of their academic success and they referred to their continuing intention to use technology for post-graduate studies. Ganassin et al. (2022) [1] also revealed that teachers think that virtual exchange may help to maintain internationalization, leading to good

international and intercultural experiences for universities in China and improving their global engagement. These results confirm the conclusions from Amankwah-Amoah et al. (2021) [17] that many of the new applications of digital technologies in universities are here to stay because of the benefits they provide. This may refer to faculty staff and students being satisfied that the digital internationalization of education is useful. The focus on internationalization may be developed via the virtualization of internationalization, which has the ability to boost internationalization at home and support the development of international and intercultural capabilities for all students in the setting of local higher education institutions [25,28,56]. By contrast, other researchers have noticed that the usefulness of the digital internationalization of education is more effective when it is merged with in-person education [57]. At the present time, college and university students want to learn more than simply the technical skills they will need to find employment; they also want to learn how to be successful learners by interacting with peers from other contexts and countries, how to communicate with people locally and globally and how to be active, adaptable members of society. A potential reason for this is that the integration of technology into teaching has become a commonplace occurrence, leading teachers to believe that technology can facilitate the sustainable internationalization of graduate education. This, in turn, is intended to foster measurable rates of achievement and growth among students.

Moreover, the internationalization dimensions, or aspects, that teachers feel are supported by technology were investigated. The findings indicated that teachers expressed a high level of contentment with the utilization of technology to facilitate collaborative online international learning, research cooperation, intercultural competence development and virtual mobility. The findings showed that teachers exhibited lower levels of contentment in utilizing technology as a means of facilitating online exchange programs and promoting the internationalization of the curriculum. This demonstrates that the online learning mode has credibility among teachers and is implemented widely as a valuable source of international learning and this is, of course, supported by technology, which is the available supportive material. Furthermore, the findings pertaining to the third question of the study unveiled that certain factors exert a direct effect on the internationalization of graduate education, whereas other factors do not. The findings indicated that the internationalization of graduate education was positively affected by collaborative online international learning, research cooperation and the development of intercultural competence. Notwithstanding the implementation of virtual mobility, online exchange programs and the internationalization of the curriculum, the internationalization of graduate education was not affected directly. It appears that the aforementioned findings substantiated and validated the conclusions derived from the study pertaining to the second research question, with the exception of virtual mobility. The aforementioned findings may show that collaborative online international learning, research cooperation and intercultural competence development had a greater impact compared to virtual mobility, online exchange programs and the internationalization of the curriculum. Chinese universities may be renowned for their efforts in establishing a superior environment that encompasses all six aspects. However, it appears that the impact varies across these aspects. The efficacy of the internationalization of graduate education in China cannot be ascertained. However, it may be of benefit to contemplate the adoption of suitable tactics to guarantee that the influence of the six facets and other variables are relatively commensurate, thereby augmenting the degree of the internationalization of graduate education. Based on the findings, it seems that the efforts to internationalize Chinese graduate education may contribute to a new phase of development, one that has been facilitated mostly by collaborative online international learning, research cooperation and intercultural competence development. These results support the study of Bruhn-Zass (2021) [55], which revealed that virtual internationalization incorporates online and distance education (ODE) as an extra category. She also showed that including stakeholders in collaborative partnerships is essential for the successful digitalization of international education, alongside structural and curricular growth. These results support the study of Rajagopal et al. (2020) [26], which showed that

open virtual mobility supports learners' skills and competencies, which are intercultural skills and attitudes; networked learning; active self-regulated learner skills; media and digital literacy; autonomy-driven learning, interactive and collaborative learning in an authentic international environment and open-mindedness. Bruhn (2020) [58] outlined a model for virtual internationalization that considers curricula, international cooperation and distance learning as well as the roles of the university strategy, administration, management and teaching staff. Similarly, Woicolesco et al. (2022) [25] found that most universities in Brazil had hosted webinars, live streams, congresses, seminars or other online academic activities throughout the COVID-19 pandemic, many of which included academics and researchers from across the world. It can be posited that China is currently experiencing a comparable trend towards the internationalization of graduate education, akin to other nations and, undoubtedly, with heightened endeavors to optimize this process.

7. Conclusions and Implications

This study aimed to better understand teachers' experiences and perspectives toward using technology in the sustainable internationalization of graduate education in China and the aspects that are supported by technology as a part of the internationalization of graduate education in China. Regarding the sampling methodology employed in this study, it adhered to a systematic approach of selecting a subset of individuals or elements from a larger population with the intention of conducting research. Specifically, participants were chosen from universities situated in Wuhan City, the epicenter from which the COVID-19 outbreak originated. In this context, the results obtained from this study could potentially serve as a representation of the circumstances observed in other educational establishments within China. Based on the findings, the situation regarding graduate education internationalization in China is acceptable, while at the same time, support and more effort from the government and teachers are required. Chinese teachers have had a positive experience with the use of technology in internationalizing graduate education and they were extremely satisfied with the use of technology to facilitate online international collaboration, online exchange programs and research cooperation. In addition, teachers were less satisfied with the use of technology to promote virtual mobility, the internationalization of the curriculum and intercultural competence. This research provides a novel perspective on the role of technology in the internationalization of graduate education in China, which was previously unclear. This study has the potential to provide Chinese policymakers with insights into the efficacy of technology and the necessary steps for Chinese universities to achieve greater internationalization. This may enable policymakers to make better-informed decisions regarding the allocation of resources aimed at promoting the utilization of technology for enhancing the sustainable internationalization of graduate education. Additionally, the current investigation has contributed advanced research on the pressing subjects of education's sustainability and internationalization, which hold substantial importance for teachers, universities and governments globally. The findings of the current research may augment the comprehension of policymakers and educators regarding teachers' perspectives on the utilization of technology to achieve sustainable internationalization of graduate education. The suggestion was made that policymakers ought to incorporate the experiences and perspectives of teachers in their assessment of the state of internationalization in Chinese universities. This is because teachers possess a deep familiarity with universities and education and are therefore well-positioned to offer insightful and valuable recommendations for the advancement of universities and education. It is recommended to enhance the integration of technology in higher education institutions through inter-university partnerships on a global scale. Additionally, the development of standardized technology-based courses is suggested to facilitate their delivery. It is possible for the government to endorse cooperation between Chinese universities and their international counterparts as a means of augmenting student engagement in such endeavors, overseen by seasoned teachers. The aforementioned results indicated that there may be diverse approaches to designing policies and implementing practices for sustain-

able internationalization in graduate education through technology in the future. In order to enhance the interest and motivation of teachers, it is recommended that the government prioritize the development of sustainable internationalization training programs that are technology-based. Moreover, it is recommended that teachers enhance their involvement with technological applications, recognize their limitations and inadequacies in utilizing technology to promote sustainable global education at the graduate level and furnish the government with this knowledge to enable the government to streamline and administer the internationalization of graduate education more effectively.

8. Limitations and Future Research Directions

There were numerous limitations to this study. This research concentrated on a single user experience scale containing several items. These items may not provide an accurate or exhaustive portrayal of teachers' experiences with technology in internationalizing graduate education. To investigate additional experiences, future research could examine a wide variety of other measures or conduct qualitative investigations. This study also concentrated on the dimensions of the internationalization of graduate education, as derived from the literature. These dimensions may not provide a comprehensive picture of the internationalization activities, which are based on technology. Future research could entail additional aspects employing distinct scales or a qualitative investigation. The current investigation employed SPSS, JASP and SmartPLS 4 as tools for data analysis. However, it should be noted that SWOT analysis was not included in this study. Subsequent studies may utilize SWOT analysis as a means to facilitate a thorough investigation and augment comprehension of the topic at hand. In Wuhan, 806 university professors responded to the survey but this demographic does not reflect that of the professors at other Chinese universities. Therefore, caution must be exercised when extrapolating these results to the entirety of the teaching staff in Chinese universities. It is strongly recommended that future research include the recruitment of teachers and students from a wide range of institutions, given that the primary focus of this study was on teachers and students. The use of a singular research methodology throughout the survey did not contribute to the study's credibility. Divergent opinions exist regarding whether or not it completely and accurately represents the opinions of the participants. Future investigations on this subject would be more persuasive if they included interview data.

Author Contributions: Conceptualization, A.B.; Methodology, Q.X. and A.B.; Software, Q.X.; Validation, Q.X.; Formal analysis, Q.X.; Investigation, Q.X.; Resources, Q.X. and A.B.; Data curation, Q.X. and A.B.; Writing—original draft, Q.X. and A.B.; Writing—review & editing, Q.X. and A.B.; Visualization, A.B.; Supervision, Q.X.; Project administration, Q.X. and A.B.; Funding acquisition, Q.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was conducted in accordance with all the required ethical considerations and practices. The study was approved by the Research Ethics Committee of the College of Humanities, Wuhan University of Engineering Science.

Informed Consent Statement: Informed consent was gathered from all participating teachers. Confidentiality was maintained by not requesting names or any other information that would identify the participants involved and they were informed of their right to withdraw from the investigation at any time.

Data Availability Statement: Data will be made available on request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Questionnaire
Dear teachers,

This questionnaire is meant to collect information about your views and perceptions about using technology to internationalize graduate education at your university. Each item has some options. Please put a tick mark (√) in the column that best represents your answer or response. The information you provide will be confidential and will strictly be used for the research purpose. I would be extremely grateful if you would give me some of your time by filling it out. Thank you very much for your help and cooperation.

Section One: Teachers' Experiences

According to your experience, do you think that using technology to internationalize graduate education at your university is:

	1	**2**	**3**	**4**	**5**	**6**	**7**	
annoying	○	○	○	○	○	○	○	enjoyable
not understandable	○	○	○	○	○	○	○	understandable
creative	○	○	○	○	○	○	○	dull
easy to learn	○	○	○	○	○	○	○	difficult to learn
valuable	○	○	○	○	○	○	○	inferior
boring	○	○	○	○	○	○	○	exciting
not interesting	○	○	○	○	○	○	○	interesting
unpredictable	○	○	○	○	○	○	○	predictable
fast	○	○	○	○	○	○	○	slow
inventive	○	○	○	○	○	○	○	conventional
obstructive	○	○	○	○	○	○	○	supportive
good	○	○	○	○	○	○	○	bad
complicated	○	○	○	○	○	○	○	easy
unlikable	○	○	○	○	○	○	○	pleasing
usual	○	○	○	○	○	○	○	cutting edge
unpleasant	○	○	○	○	○	○	○	pleasant
secure	○	○	○	○	○	○	○	not secure
motivating	○	○	○	○	○	○	○	demotivating
meets expectations	○	○	○	○	○	○	○	does not meet expectations
inefficient	○	○	○	○	○	○	○	efficient
clear	○	○	○	○	○	○	○	confusing
impractical	○	○	○	○	○	○	○	practical
organized	○	○	○	○	○	○	○	cluttered
attractive	○	○	○	○	○	○	○	unattractive
friendly	○	○	○	○	○	○	○	unfriendly
conservative	○	○	○	○	○	○	○	innovative

Section Two: Teachers' Perspectives

Dimension		Items	SD	D	N	A	SA
Online exchange programs	1.	I think the exchange of programs with other institutions throughout the globe was performed well.					
	2.	Technology enabled us to share material with program creators.					
	3.	Technology made it possible to exchange programs quickly.					
	4.	Technology assisted groups of program designers in determining the demands of each university's curriculum.					
	5.	Technology helped arrange seminars with other teachers to examine program flaws and reproduce them by sharing experiences.					
Virtual mobility	6.	Technology allows for cross-border online student cooperation that improves knowledge sharing.					
	7.	Technology has increased students' access to platforms at other colleges.					
	8.	Technology increases access for all students to other institutions' platforms and courses.					
	9.	Virtual mobility is a more ecologically friendly option thanks to technology.					
	10.	By using technology, virtual mobility is more environmentally sustainable.					
Collaborative online international learning	11.	The utilization of technology enables both my students and myself to engage in international communication and collaboration with peers via online platforms.					
	12.	The utilization of technology offers supplementary educational opportunities for students from China and other nations to engage in interactive and collaborative learning experiences, thereby fostering a sense of ownership over their academic pursuits.					
	13.	The utilization of technology facilitates collaborative learning, which seeks to foster a sense of shared responsibility among students from China and other nations, thereby placing the onus of learning on the students themselves.					
	14.	The utilization of technology enables students to engage in collaborative work with their peers, facilitating their role as the initiator and generator of novel insights throughout the iterative stages of research, interpretation, dissemination and adjustment.					
	15.	The implementation of technology in education has the potential to enhance communication and facilitate a sustainable and affordable online learning experience that is accessible to a wider range of students, rather than being limited to a privileged few.					
	16.	Students can use technology to accurately diagnose learning competencies as part of evaluation and assessment.					

Dimension		Items	SD	D	N	A	SA
Internationalization of curriculum	17.	Technology enabled the sharing of pedagogical practices and educational exercises that encompass interventions aimed at facilitating the acquisition of competencies and understanding among students.					
	18.	The utilization of technology facilitates a systematic collaboration with international educators to analyze potential challenges within the academic program for students.					
	19.	The utilization of technology has facilitated the collaboration of culturally heterogeneous course/program teams, providing them with the chance to jointly assess and enhance educational curricula.					
	20.	The utilization of technology has facilitated a diverse array of educational endeavors, including foreign language curricula.					
	21.	The utilization of technology has facilitated a diverse array of initiatives that encompass curricula designed to specifically address the development of knowledge and competencies.					
	22.	Teachers and students use social media to bridge the gap between local and nonlocal program content.					
	23.	The utilization of technology has facilitated a wide array of initiatives, including curricula that result in joint or double degrees.					
Research cooperation	24.	The utilization of technology enables academic personnel to participate in global conferences, encompassing cross-disciplinary and inter-professional gatherings.					
	25.	The utilization of technology enables educators to conduct research and disseminate their findings, thereby facilitating the progress of academic inquiry and the implementation of practical reforms.					
	26.	The utilization of technology enables individuals to engage in collaborative research endeavors on an international level, thereby creating prospects for mutually beneficial partnerships and the resolution of global challenges.					
	27.	The online interactions between scientists and individuals from diverse nationalities and cultures are likely to yield novel ideas and advancements in problem-solving.					
	28.	Technology supports research that spans national boundaries to be applied to a wide range of people and cultures.					
Intercultural competence development	29.	The utilization of technology has expanded the possibilities for intercultural and transnational education.					
	30.	The employment of technology has enabled a broad spectrum of endeavors that particularly target the cultivation of cross-cultural and intercultural proficiencies.					
	31.	The integration of technology has facilitated global collaboration among students, enabling them to engage in academic pursuits without the need for cultural differences interruption.					
	32.	Technology enables students to effectively and appropriately communicate and behave in intercultural situations.					
	33.	The integration of technology has enabled a broad spectrum of endeavors that encompass a variety of components and actions, such as the assimilation of content from diverse cultures.					
	34.	The integration of technology enables substantial communication among my students, myself and colleagues located in remote areas and possessing varying linguistic and cultural heritages.					

Dimension		Items	SD	D	N	A	SA
Internationalization of graduate education	35.	It is easy for students to network with their counterparts in classrooms and universities situated in faraway nations					
	36.	I have experienced a transition from isolation to interdependence and from connectivity to hyperconnectivity.					
	37.	I am more involved in cooperation and networking with other teachers from other countries					

Gender: Male □ Female □
Level: Assistant professor □ Associate professor □ Professor □
Age:
29–34 years old □
35–40 years old □
41–45 years old □
46 years and older □
Thank you

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Article

Teachers' Acceptance of Online Teaching and Emotional Labor in the EFL Context

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Abstract: The recent growth and sustainability in online education have led to a greater demand for language teachers to accept online teaching and a heightened focus on language teachers' emotions in an online setting. Based on the Technology Acceptance Model (TAM), this study attempted to investigate the relationship between English as a Foreign Language (EFL) teachers' acceptance of online teaching and their emotional labor in online teaching. A questionnaire was distributed to 338 EFL teachers working at 19 middle schools and 24 high schools in China, and 10 teachers were interviewed. Following a series of analyses of the data, a structural relationship model integrating acceptance of online teaching and online teaching emotional labor strategies was developed and tested. The results indicate that EFL teachers' acceptance of online teaching significantly predicts three emotional labor strategies in online teaching. Specifically, EFL teachers' acceptance of online teaching positively influences deep acting and expression of naturally felt emotions, while negatively affecting surface acting. The obtained results address important theoretical, methodological, and practical gaps by examining the interplay between acceptance of online teaching and emotional labor in the context of online language education, a dimension that previous studies have largely overlooked.

Keywords: EFL teachers; teachers' acceptance of online teaching; emotional labor; online teaching environments; structural equation modelling

Citation: Peng, R.; Hu, Q.; Kouider, B. Teachers' Acceptance of Online Teaching and Emotional Labor in the EFL Context. *Sustainability* **2023**, *15*, 13893. https://doi.org/10.3390/su151813893

Academic Editors: Barry Lee Reynolds, Rustam Shadiev and Rui Li

Received: 22 August 2023
Revised: 11 September 2023
Accepted: 12 September 2023
Published: 19 September 2023

1. Introduction

There has been remarkable success in spreading and sustaining English-language teaching over the world in recent decades [1]. This expansion and sustainability may be traced back to the fact that English is valued for its ability to boost sustainable economic growth and national progress. This growth pattern parallels the rapid development of new technologies [2]. The many advantages it provides to both teachers and students have contributed to its widespread adoption. As a result, there has been growth in adopting online teaching [3]. Literature demonstrated that online teaching offers advantages over traditional face-to-face instruction by overcoming spatial and temporal constraints, enabling remote interaction and access to diverse learning resources [4]. However, it also has limitations such as reduced interactivity and limited teaching content diversity [5,6], which raises concerns among teachers regarding the limited utilization of online teaching platforms and available technological resources [7]. At the same time, within online teaching, the intricate interaction between temporal and geographical isolation presents a unique challenge that compels teachers to adopt novel roles while effectively regulating their own emotional reactions. The implementation of this change is of paramount importance in order to maintain sustainability in the online instructional methodology [8]. As a result, the online teaching environment places increased demands on instructors' emotional expressions, requiring them to engage in what is referred to as emotional labor [9].

Emotional labor has an immediate and significant effect on the quality of instruction performed by instructors [8,9]. Teachers' emotional investment in their classrooms

has a significant impact on their motivation, concentration, and overall instructional outcomes [8,10,11]. The ability of a teacher to control their emotions is essential for fostering a positive and engaging online learning environment [1], which increases student engagement and retention rates. Teachers are being compelled to reassess and adjust the emotional labor they dedicate to the online education environment due to its dynamic character [8]. Hence, teachers are faced with the need to adapt their emotional involvement in order to address sustainable online teaching. The implementation of this transformation is crucial in order to guarantee that the emotional labor performed is effectively aligned with the complexities of distance education. The need for this adaptation necessitates a reassessment of the dynamics of emotional work in online education environments [8]. Nonetheless, the process of transitioning is subject to the effect of technological advancements on human emotions and the ongoing integration of technology into the realm of emotional labor [12]. The act of openly expressing emotions in the context of online education poses difficulties that are associated with the process of adapting to technology [8,13,14]. The dynamic nature of technology enables teachers to use diverse approaches to regulating their emotions throughout various virtual environments. Teachers have the ability to adapt their communication strategies, methods of sharing information, and ways of responding in accordance with their emotional displays. The adoption of online teaching by teachers has a crucial role in shaping their emotional experiences and actions, ultimately impacting the results of online education [4,7]. Hence, the lack of positive acceptance towards online teaching might result in resistance, changes in emotional labor practices, and adverse effects on perceived teaching outcomes [10]. In light of these complexities, there exists a need to investigate EFL teachers' acceptance of online teaching and its impact on their emotional labor strategies. Pertaining to this, this study attempted to investigate how EFL teachers' acceptance of online teaching affects their emotional labor strategies. Given that the interaction between teachers and students in online learning environments can be both asynchronous and synchronous, recognizing the increase in the synchronous mode of online teaching forms, this study focuses on the synchronous mode of online teaching forms.

The objective of the study was to facilitate a well-informed decision-making process for the advancement of emotional labor in online teaching within the context of China. The findings of this study hold promise for policymakers and teachers in various nations seeking to augment the level of sustainable technology integration in pedagogy and the management of emotional labor in online teaching. Furthermore, the ongoing study possesses the capability to provide novel scholarly insights into the urgent matter of sustainability in technology adoption and emotional labor in online education, which carry significant significance for teachers, educational establishments, and governmental entities across the globe. The present research has made a valuable contribution to the understanding of the viewpoints held by teachers regarding the implementation of technology and the emotional labor involved in online teaching, with the aim of enhancing the quality of EFL education.

2. Literature Review

2.1. Technology Acceptance Model and Acceptance of Online Teaching

The Technology Acceptance Model (TAM), originally proposed by Davis (1985; 1989) [15,16], is a widely utilized and influential model in the field of information technology. TAM emphasizes the role of technology acceptance in shaping users' attitudes and behaviors towards the utilization of new technologies [16]. It has gained substantial recognition and validation for analyzing the behaviors of students and instructors in relation to the utilization of emerging technologies across diverse educational settings [17–19]. In TAM, Perceived Usefulness (PU) and Perceived Ease of Use (PEU) are recognized as the two principal determinants that significantly influence individuals' technology acceptance [16,20]. In online learning environments, PU refers to users' perception of how online learning improves teaching and learning outcomes, while PEU refers to users' perception of the ease

of using specific technology [18,21]. When teachers perceive online teaching technology as easy and requiring less effort, they are more inclined to continue using it [21].

Online teaching is an educational approach facilitated by digital technologies, enabling teachers and students to engage in interactive learning anytime and anywhere [22]. Teachers' acceptance of the new technology and their willingness to use online technologies are essential for effective online teaching [16]. Technology acceptance significantly influences teachers' intention to continue utilizing online teaching platforms [7]. While TAM has been widely used to explore online teaching acceptance [19,23], there is limited empirical research on TAM in relation to teachers' emotional labor. EFL teachers' acceptance of online teaching predicts their active participation and recognition of the benefits of this instructional mode. Greater acceptance leads to increased efforts in overcoming emotional barriers, regulating emotion actively, and engaging in teaching wholeheartedly. Thus, it is worth exploring whether teachers' acceptance of online teaching can influence their choice of emotional labor strategies in online teaching environments.

2.2. Emotional Labor in Teaching

The idea of emotional labor, as first proposed by sociologist Arlie Hochschild in 1983, refers to the process of actively managing one's emotions in order to display detectable facial and body responses [24]. The concept mentioned has had a significant impact on the study of emotional labor, which is acknowledged as a separate kind of labor in addition to mental and physical labor within work environments [24]. At the core of this theoretical framework lie the principles governing emotions and feelings. These principles contain the overt or covert expectations established by companies, dictating that workers must exhibit appropriate emotions towards service recipients within certain settings [24]. According to Hochschild (1983) [24], there are three key requirements that delineate the nature of employment that entails emotional labor. These criteria include: (a) engaging in direct face-to-face and voice-to-voice encounters with the general public, (b) aiming to elicit certain emotional reactions in others, and (c) exercising management and control over emotional interactions.

While emotional labor was initially associated with service-oriented industries like flight attendants and doctors, the teaching profession has also been recognized as a context where emotional labor is required. This recognition is based on the criteria established by Hochschild (1983) [24] and has been supported by various studies [25–28]. The concept of teachers' emotional labor encompasses the deliberate adjustment, control, and administration of emotions and their manifestation, influenced by normative convictions, cultural anticipations, and the emotional display regulations inherent in the field of teaching [26,27,29–31]. Teachers possess inherent knowledge about the need to conform to certain laws that regulate the manifestation of emotions during instructional sessions inside the classroom. These regulations include the exhibition of positive emotions and the inhibition of negative emotions [9,32,33]. In addition, the concept of emotional labor involves the process of regulating and managing emotions, as discussed by Hochschild (1983) [24] and Grandey (2000) [34]. It is widely recognized as a crucial component of teachers' professional lives, as highlighted by Constanti and Gibbs (2004) [35] and Gkonou and Miller (2020) [36]. The act of engaging in emotional labor allows instructors to effectively convey good feelings throughout their teaching practices [25,37], hence facilitating successful communication between teachers and students [38,39]. The scholarly examination of teachers' emotional labor has primarily focused on four main inquiries: (a) the effects of emotional labor, as explored by Yin (2009, 2015) [27,40], Hülsheger et al. (2010) [41], Lyndon et al. (2021) [42], Yilmaz et al. (2015) [43], and Yin et al. (2013) [44], (b) the strategies employed by teachers to manage emotional labor, as investigated by Yin (2012) [30] and Beltman and Poulton (2019) [45], (c) the factors that influence teachers' emotional labor, as studied by Basim et al. (2013) [46] and Thies and Kordts-Freudinger (2019) [47], and (d) the measurement of teachers' emotional labor strategies, as examined by Yin (2012) [30] and Ma et al. (2023) [11]. In order to participate in emotional labor effectively, teachers use many ways to manage and

regulate their emotions. These tactics include Surface Acting (SA), Deep Acting (DA), and the authentic expression of naturally felt emotion (ENFE). Surface Acting (SA) comprises the act of displaying emotions that are not experienced, while Deep Acting (DA) entails the deliberate modification of one's emotions in order to convey desired emotional states. Previous research has examined both methodologies [24,34,48]. Furthermore, the manifestation of innate emotions entails the authentic and spontaneous experience and communication of emotions that are consistent with the norms and standards of a professional context [40,49]. However, in the realm of language education, there has been a notable upsurge in scholarly inquiry about the substantial impact of emotions on the experiences of teachers and students [50]. Significant attention has been directed to the phenomenon of emotional work among language instructors in traditional classrooms [29]. While a substantial body of research has focused on the emotional labor methods used by instructors in traditional face-to-face teaching settings, there is a paucity of empirical studies that have explored this phenomenon in the online educational environment [8,9,13,14].

3. The Present Study

Previous studies have confirmed that factors such as the adaptation to online teaching, the invisibility of the online teaching space, and the peripheral environment surrounding the teachers can influence teachers' online teaching emotional labor [8,13]. The adaptation to online teaching technology has been found to have the most significant impact on teachers' emotional labor. However, the existing research has not specifically investigated the influence of acceptance of online teaching on teachers' emotional labor strategies in online teaching. Therefore, this study aimed to explore the effect of EFL teachers' acceptance of online teaching on their emotional labor within an online teaching context, drawing upon the TAM. The research questions of this study were as follows:

A. To what extent do Chinese EFL teachers accept online teaching after experiencing online teaching?
B. What are Chinese EFL teachers' online teaching emotional labor strategies?
C. How does Chinese EFL teachers' acceptance of online teaching affect their online teaching emotional labor strategies?

4. Materials and Methods

4.1. Participants

The participants were 338 EFL teachers (242 women, 96 men) employed at middle (45%) or high schools (55%) in China. Although 381 teachers originally participated, 43 respondents with the same answers for all items, missing responses, or without online teaching experience were removed from the data analyses. The teachers' ages ranged from 24 to 55 years old (mean = 33.2, SD = 6.316), with 122 (36.09%) aged 31 to 40, 75 (22.19%) aged 41 to 50, 38 (11.24%) aged 51 to 60, and 103 (30.48%) aged 21 to 30; 228 (67.46%) held a bachelor's degree, and 103 (30.47%) and 7 (2.07%) held a master's degree and a doctor's degree, respectively. With a range of 0 to 27 years of experience teaching English in middle or high schools, the participants had generally taught English for 13.26 (SD = 6.975) years. All the participants had experienced EFL online teaching. Ten EFL teachers (referred to as A, B, C, D, E, F, G, H, I, and J to protect their anonymity) were selected for interviews using purposive sampling. These teachers represent a diverse range of backgrounds and come from three middle schools and five high schools across China. They had been required to teach online via different online teaching platforms (e.g., Tencent Meeting) for 3 to 12 months. This group of teachers, consisting of five males and five females, exhibited a diverse range of characteristics, including their educational background, teaching specialties, and gender. This careful selection ensured a comprehensive representation of perspectives. It is noteworthy to emphasize that these teachers had embarked on this mode of instructional delivery without prior formal guidance or structured training, and their familiarity with online teaching remained comparatively limited. Before completing the questionnaire and engaging in teacher interviews, the participants were informed of the

purpose of the study and that the results of data collection would be intended solely for academic purposes. They would not be identified through any report in this study. They volunteered to complete the questionnaire and to be interviewed.

4.2. Instruments

The research employed three instruments: an eight-item background questionnaire, a seven-item AOT (Acceptance of Online Teaching) scale, and an 18-item online emotional labor scale. In the introductory section of the questionnaires, it was clearly conveyed that participation was voluntary and anonymous. Responses to the questionnaire were intended exclusively for research purposes and were not intended for commercial or any other utilization.

Background information. The background survey included questions about teachers' contextual (school level) and personal information (gender, age, educational level, teaching years, and online teaching experience).

Acceptance of online teaching. The seven-item AOT scale used in this study (Cronbach's $\alpha = 0.937$) was modified from that designed by Sun and Zou [7] (2022) and Venkatesh et al. (2003) [51]. The questionnaire was designed with a total of seven items encompassing the two dimensions of PU (Perceived Usefulness) and PEU (Perceived Ease of Use). The resulting AOT scale items were placed on a 5-point Likert-type scale, with values of 1 to 5 assigned to the five descriptors ranging from "strongly disagree" to "strongly agree," respectively.

Online teaching emotional labor strategy. The questionnaire consists of 18 items and has a reliability coefficient of 0.779. It was initially composed of 20 items but was later revised to include 18 items. In accordance with Ma et al. (2023) [11], item statements within a questionnaire are achieved through diverse methodologies encompassing the integration of qualitative data as well as existing scales. The process of item derivation for the present questionnaire followed a sequential procedure, whereby qualitative data collection served as the initial phase, as previously detailed in the scholarly contribution by Aydın (2016) [52]. Thus, before deciding on the questionnaire items, interviews were conducted with teachers first, focusing on the methods that teachers use to manage their emotions in online settings, the impact of online teaching on the expression of their emotions, and the factors influencing their emotional labor in online teaching. The interview outline can be seen in Appendix A. After conducting interviews with teachers, a content analysis approach was employed to systematically examine the insights provided by teachers. With the guidance of the analytical framework of the current study, different codes and signs related to online emotional labor were carefully reviewed. Based on the responses gathered from the interviews, three types of teachers' online teaching emotional labor strategies were identified: SA, DA, and ENFE (Table 1). For example, we categorized strategies where teachers pretend unfelt emotions or hide felt emotions in the online teaching environment as "SA", and strategies where teachers employ cognitive techniques to modify their felt emotions as "DA". The data describing that teachers directly expressed emotions in the online teaching process were coded as "ENFE". Teachers interviewed explicitly and implicitly indicated differences in emotional expression between online and offline teaching. Their responses were summarized and categorized using keywords mentioned by the teachers (see Table 1).

A literature review was conducted to establish a theoretical basis, including the concepts and features of teachers' emotional labor [25,26,40], as well as the analysis of teachers' emotional labor in online contexts [9,14]. Then we referred to the detailed information in the teacher emotional labor strategy scale [30], teachers' emotional labor strategy in classrooms [11], and student teachers' emotional labor strategy [53]. Items that fit the online setting were collected from these existing scales [11,30,53,54]. The initial questionnaire was developed as a three-factor model (SA, DA, ENFE) involving 20 descriptive items that were scored on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree" (See Appendix B). Then, Exploratory Factor Analysis (EFA) and Cronbach's α were employed

to revise the questionnaire's items and maintain the salient items. EFA was conducted to determine the proper factors. Cronbach's α examined the reliability, which ranges from 0.880 to 0.938. Finally, an 18-item formal questionnaire was formed. Since the original questionnaire was developed in English, all items were translated into Chinese following the translation-back-translation procedure [55].

Table 1. Online teaching emotional labor strategies profiles of the interviewees.

Online Teaching Emotional Labor Strategies	No. of Interviewees	Interviewees
Hiding real emotions	3	T1, T2, T9
Faking a positive emotion	3	T1, T3, T9
Suppressing negative emotions	3	T2, T3, T9
Attentional deployment through recalling pleasant memories	6	T4, T5, T6, T7, T8, T10
Cognitive shifting to consider students' perspectives	5	T4, T5, T7, T8
Displaying genuine and authentic emotions during online teaching	7	T2, T4, T5, T6, T7, T8, T9
Expressing satisfaction sincerely	5	T3, T4, T5, T7, T8
Showing anger naturally	4	T5, T6, T7, T8

4.3. Data Collection and Analyses

Two types of data were collected from the questionnaire and interview. In the present study, a method of simple random sampling was employed, and the online questionnaire was hosted on Wenjuanxing (www.wjx.cn) (accessed from 23 February to 28 March 2023), a reputable online survey platform extensively used in China. The survey, accompanied by an informed consent form, was subsequently distributed online to potential respondents across various regions of China over a span of one month through platforms including WeChat and email. The data obtained from the questionnaire were analyzed using SPSS version 22, JASP, and AMOS version 22. Firstly, EFA was performed to extract the main factors and remove items that did not meet the requirements for factor extraction. Secondly, reliability analysis and Confirmatory Factor Analysis (CFA) were conducted to test the internal consistency and validity of the revised questionnaire. A revised 18-item questionnaire was constructed. Thirdly, descriptive statistical analysis was conducted to gain an overall understanding of EFL teachers' acceptance of online teaching and their online teaching emotional labor strategies. Finally, Structural Equation Modelling (SEM) was employed to examine the relationship between EFL teachers' acceptance of online teaching and their online teaching emotional labor strategies. Ten EFL teachers were randomly selected for interviews, which served two purposes: questionnaire design and interpretation of questionnaire data results. The interview questions focused on how teachers express and manage their emotions when interacting with students in online teaching environments, the strategies they employ to regulate emotions when their true feelings differ from the required emotions, and the factors influencing emotional labor in online teaching contexts.

5. Results

5.1. Validity and Reliability

Drawing upon the works of Venkatesh and Davis (2000) [56] and Davis (1989) [16], a two-factor solution was employed to assess acceptance of online teaching. The results showed that the Kaiser–Meyer–Olkin (KMO) statistic obtained was 0.924 (>0.7) and Bartlett's test of sphericity was significant (χ^2 = 1925.388, df = 21, p = 0.000 < 0.001), indicating that the selected sample size and data collection meet the requirements for conducting factor analysis. Through orthogonal rotation, which converged after five times of iteration rotation, two latent factors were extracted by adopting an eigenvalue greater than 1.0 and factor loading greater than 0.40 [57]. Higher eigenvalues represent factors that account

for more variance in the observed variables [58]. The eigenvalues for the two factors were 5.103 and 1.626, respectively, which means two latent factors explain a substantial amount of variance in the observed variables [58]. Factor 1, labelled as Perceived Usefulness (PU), included four items pertaining to concerns regarding the efficacy of online teaching, its impact on teaching and learning outcomes, and the utilization of online teaching methods. This factor accounted for 44.021% of the total variance. Factor 2, labelled as Perceived Ease of Use (PEU), explained 37.810% of the total variance and comprised three items related to the perceived ease of using online teaching technology. The factors loading for the acceptance of online teaching items are presented in Table 2.

To examine the internal structure of the original 20-item questionnaire on EFL teachers' online teaching emotional labor strategies and conduct factor extraction, the first EFA was performed using principal component analysis and varimax orthogonal rotation. The iteration rotation process was repeated seven times until convergence was achieved. The results revealed a KMO statistic of 0.911 (>0.7), indicating that the sample size and data collection met the requirements for factor analysis. Additionally, Bartlett's test of sphericity was significant (χ^2 = 4991.220, df = 190, p = 0.000 < 0.001), further supporting the suitability of the data for factor analysis. Similarly, a second EFA was conducted, during which two descriptive items related to online teaching emotional labor strategies (Items sa7 and sa8) were removed due to cross-loading. The results showed a KMO value of 0.920 (>0.7), and Bartlett's test of sphericity was significant (χ^2 = 4613.038, df = 153, p = 0.000 < 0.001). Using orthogonal rotation, which underwent six iterations, three latent factors were extracted by applying a criterion of eigenvalues greater than 1.0 and factor loading exceeding 0.40 [57].

Table 2. Results of the exploratory factor analysis.

Component	Item Statement	Factor Loading	Eigenvalues	% of Variance
Perceived Usefulness	pu2. Both online and offline teaching methods possess the capability to improve students' language learning outcomes.	0.873	5.103	44.021
	pu1: Online teaching will increase my productivity in my English teaching.	0.828		
	pu3. Online teaching enhances my English teaching effectiveness.	0.787		
	pu4. In general, online teaching proves to be an effective approach to English instruction.	0.736		
Perceived Ease of Use	peu3. I quickly became proficient in operating online teaching software.	0.858	1.626	37.810
	peu1. I find the operation of online teaching software to be straightforward.	0.812		
	peu2. The operation steps of online teaching software platforms are clear and comprehensible.	0.751		
Surface Acting	sa4. In conflicts with students, I suppress any feelings of displeasure.	0.828	1.273	21.629
	sa5. In cases of student misconduct, such as skipping classes, I restrain my own discontent.	0.797		
	sa2. I artificially display enthusiasm, even if it does not genuinely reflect my inner state.	0.775		
	sa3. When faced with network interruptions or technical malfunctions, I maintain composure despite feeling flustered.	0.768		
	sa6. Even in instances of copying homework, I do not show any internal displeasure.	0.729		
	sa1. Despite feeling tired, I pretend I have energy.	0.721		

Table 2. *Cont.*

Component	Item Statement	Factor Loading	Eigenvalues	% of Variance
Deep Acting	da5. When experiencing anxiety during online teaching, I make an effort to calm myself by appreciating the merits of online teaching.	0.818	2.694	22.285
	da6. I actively strive to genuinely experience the positive emotions that I need to display while teaching online.	0.814		
	da4. Despite any personal displeasure, I am able to maintain a joyful disposition while delivering my online classes.	0.753		
	da3. Even when facing resistance towards online teaching, I redirect my attention towards positive aspects as much as possible.	0.683		
	da2. In cases of student mistakes, such as copying homework, I consciously calm myself and initiate a conversation with the student.	0.665		
	da1. When students' performance in online learning is unsatisfactory, I employ perspective-taking techniques to prevent anger from arising.	0.578		
Expression of Naturally Felt Emotion	en2. Positive feedback from students greatly boosts my confidence in online teaching.	0.862	8.524	25.478
	en6. In cases where students lack engagement during class, I openly display my discontent.	0.848		
	en4. When students actively participate and provide insightful answers, I feel a strong sense of accomplishment.	0.813		
	en3. When students fail to pay attention in class, I openly express my disappointment.	0.806		
	en5. When students are in a good state, it enhances my enthusiasm for online teaching.	0.803		
	en1. When students make progress after online learning, it brings me a profound sense of gratification.	0.543		

After the EFA, a revised questionnaire on online teaching emotional labor strategies was developed, comprising 18 descriptive items that could be classified into 3 types: SA (6 items), DA (6 items), and ENFE (6 items). Refer to Table 2 for the specific breakdown. The loading values of the items in both acceptance of online teaching and online teaching emotional labor strategies, as well as the eigenvalues and variance explanatory rates of the factors, are also provided in Table 2. In terms of the acceptance of online teaching, the factor loading of the seven descriptive items ranged from 0.736 to 0.873. Concerning online teaching emotional labor strategies, the factor loading of the 18 descriptive items ranged from 0.543 to 0.862.

In addition, the measurement model was assessed using multiple fit indices, including $\chi^2/df = 7246.651$, the Root Means Square Error of Approximation (RMSEA) = 0.087, the Comparative Fit Index (CFI) = 0.903, the Goodness of Fit Index (GFI) = 0.978, Standardized Root Mean Square Residual (SRMR) = 0.057, and the Tucker–Lewis Index (TLI) = 0.890. All these values of the fit indices seemed to be appropriate, and they confirmed the validity of the proposed model, and that the final six-factor model fit well. The Cronbach's alpha (α) value for perceived usefulness is 0.925, perceived ease of use is 0.880, SA is 0.884, DA is 0.890, and ENFE is 0.938. The Average Variance Extracted (AVE) for all variables was adequate as they are higher than 0.50, indicating a good approximation of validity: The average variance extracted of perceived usefulness is 0.754, perceived ease of use is 0.712, SA is 0.582, DA is 0.595 and ENFEs is 0.735. The composite reliability for each factor was 0.246, 0.288, 0.418, 0.405, and 0.265. In order to evaluate discriminant validity, each

factor that contained the AVE was also tested with the squared correlation. The proof of discriminant validity was satisfactory.

5.2. Descriptive Statistics and Correlations

Table 3 presents the descriptive analysis results for acceptance of online teaching and online teaching emotional labor strategies, including the means and Standard Deviations (SD). According to TAM [56], if individuals exhibit a higher PEU and PU regarding information technology, it typically implies a greater level of acceptance of that information technology. The findings indicate that teachers obtained moderate scores for perceived usefulness (M = 3.43, SD = 0.89), perceived ease of use (M = 3.65, SD = 0.86), and overall acceptance of online teaching (M = 3.52, SD = 0.88). Among the three types of online teaching emotional labor strategies, teachers demonstrated the highest inclination towards the ENFE (M = 3.74, SD = 0.89), followed by DA (M = 3.47, SD = 0.88), and the least inclination towards SA (M = 3.04, SD = 0.94). Analyzing the descriptive statistics, it is apparent that the mean scores for all variables fall within the range of 3 to 4. The rating scale employed in this study is a positively oriented Likert scale ranging from 1 to 5, conceptualized as extending from one extreme to another—low to high, small to large, negative to positive, or weak to strong [59]. Consequently, it can be inferred that the EFL teachers in this study display an above-average level of acceptance towards online teaching and demonstrate a consistent inclination towards specific emotional labor strategies.

Table 3. Descriptive statistics and correlation matrix (n = 338).

Variables	M	SD	1	2	3	4	5	6	7
AOT	3.52	0.88	1						
PU	3.43	0.89	0.962 **	1					
PEU	3.65	0.86	0.925 **	0.785 **	1				
OTELS	3.42	0.90	0.495 **	0.474 **	0.461 **	1			
DA	3.47	0.88	0.715 **	0.676 **	0.677 **	0.776 **	1		
SA	3.04	0.94	−0.532 **	−0.498 **	−0.511 **	0.108 *	−0.410 **	1	
ENFE	3.74	0.89	0.653 **	0.622 **	0.613 **	0.789 **	0.728 **	−0.416 **	1

** $p < 0.01$; * $p < 0.05$. Note. AOT = Acceptance of Online Teaching; PU = Perceived Usefulness; PEU = Perceived Ease of Use; OTELS = Online Teaching Emotional Labor Strategies; DA = Deep Acting; SA = Surface Acting; ENFE = Expression of Naturally Felt Emotions.

Regarding the correlation between acceptance of online teaching and online teaching emotional labor strategies, Table 3 shows that there are significant correlations between the acceptance of online teaching and the three sub-variables of online teaching emotional labor strategies at the 0.01 level. The correlation matrix in Table 3 indicates that all factors significantly correlated with each other. In general, significant correlations were found among the three online teaching emotional labor strategies, but it was noted that SA negatively correlated with all other variables ($p < 0.01$). Moreover, a negative and stronger correlation was found between SA and acceptance of online teaching (r = −0.532, $p < 0.01$). Significant correlations, in a positive direction, were found between acceptance of online teaching and all other factors except SA. Although significant correlations were found between acceptance of online teaching and all other factors, the correlations between acceptance of online teaching and DA (r = 0.715, $p < 0.01$) were higher than those between acceptance of online teaching and other factors. Moreover, it was found that acceptance of online teaching displayed relatively stronger correlations with online teaching emotional labor strategies as a whole (r = 0.653, $p < 0.01$).

5.3. Structural Equation Modelling

To examine the specific relationship between the EFL teachers' acceptance of online teaching and emotional labor strategies within online teaching contexts, path analysis was conducted using structural equation modelling. The results of the goodness-of-fit measures reveal that the structural model has a good fit to the data (χ^2/df = 2.788, normed fit index

(NFI) = 0.900, Tucker–Lewis Index (TLI) = 0.923, Comparative Fit Index (CFI) = 0.933, Root Means Square Error of Approximation (RMSEA) = 0.073) (Table 4).

Table 4. Path analysis results of model fits.

	χ^2/df	NFI	TLI	CFI	GFI	AGFI	RMR	RMSEA
Threshold value	1–3	>0.80	>0.90	>0.90	>0.90	>0.80	<0.80	<0.80
Index value	2.788	0.900	0.923	0.933	0.873	0.824	0.047	0.073

As shown in Figure 1, acceptance of online teaching is a significant predictor of online teaching emotional labor strategies. Specifically, acceptance of online teaching has positive impacts on DA (β = 0.79, $p < 0.001$) and ENFE (β = 0.67, $p < 0.001$), while it has negative impacts on SA (β = −0.58, $p < 0.001$). Acceptance of online teaching is reflected by seven pathways, with standard path coefficients ranging from 0.75 to 0.89; all the estimates are significant at the 0.001 level. Furthermore, DA can be explained by six pathways, with standard path coefficients ranging from 0.58 to 0.84 and significant at the 0.001 level. ENFE can be reflected by six pathways (their standard path coefficients are 0.68, 0.84, 0.85, 0.87, 0.89, and 0.92, respectively, with a significance level of 0.001). Additionally, SA is explained by six pathways, with standard path coefficients ranging from 0.63 to 0.85; all the estimates are significant at the 0.001 level.

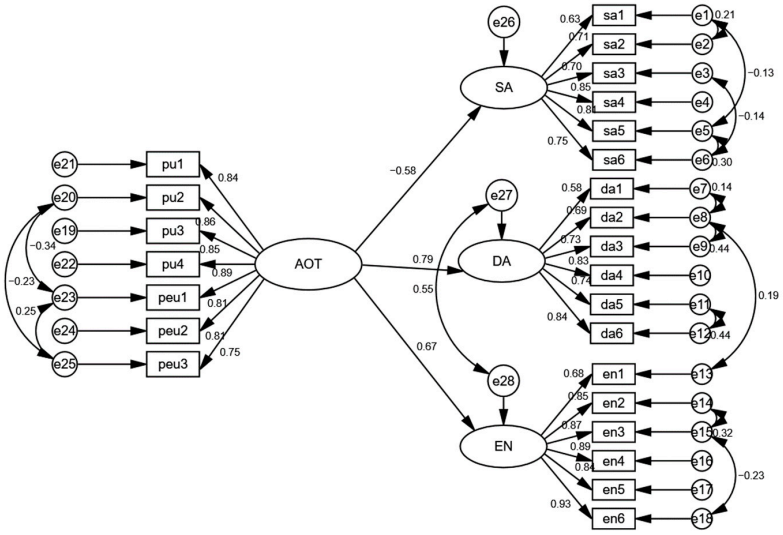

Figure 1. Structural equation model of pathways from acceptance of online teaching to online teaching teaching emotional labor strategies. Note: AOT = Acceptance of Online Teaching; SA = Surface Acting; DA = Deep Acting; EN = Expression of Naturally Felt Emotions.

6. Discussion

This study aimed to explore the effect of EFL teachers' acceptance of online teaching on their emotional labor within an online teaching context. Firstly, drawing upon the TAM framework proposed by Venkatesh and Davis (2000) [56], this study revealed that EFL teachers displayed favorable acceptance of online teaching. Specifically, EFL teachers perceived online teaching as highly useful. This implies that EFL teachers believe that incorporating online teaching can enhance teaching and learning outcomes, which is consistent with previous research findings [18,21]. Additionally, EFL teachers found online teaching technology tools to be user-friendly and easy to use. These findings are consistent with numerous studies that have investigated teachers' acceptance of online teaching using the TAM framework [7,18,60,61]. However, it is worth noting that while studies exploring the acceptance of online teaching among teachers exist [7,17], research specifically

addressing the acceptance of online teaching among middle and high school EFL teachers has been lacking. Therefore, the present study sets a precedent about a topic not being addressed in the existing literature: EFL teachers' acceptance of online teaching in middle and high school settings. Furthermore, the mean scores for perceived ease of use were significantly higher than those for perceived usefulness and the overall scale scores for the entire sample. It indicates that teachers perceived the technology used in online teaching as easy to use and navigate. These results were further supported by insights gathered through interviews conducted with EFL teachers. During the interviews, participants were asked about their opinions on online teaching and to discuss the advantages and disadvantages of online teaching. Among the 10 EFL teachers interviewed, 7 mentioned that the ease-of-use of online teaching technology and the usefulness of online teaching were factors that facilitated their willingness to learn new teaching technologies and enhance their motivation to teach online.

One potential factor contributing to the moderately high level of acceptance of online teaching among EFL teachers in this study could be the influence of the external environment. Given that technology-assisted teaching has become the norm in the current era [62–64], instructors have a strong motivation to acquire online teaching technology, and their perceived usefulness of online teaching has increased as a result. Additionally, EFL teachers in this study expressed beliefs that online teaching offered advantages over traditional teaching in various aspects, such as enhancing students' autonomous learning abilities, providing flexibility in learning time and location, and offering abundant teaching resources. This finding aligns with the findings of Wingo et al. (2017) [65], who reported that instructors highly value students' success in an online learning environment.

Taken together, these findings provide strong evidence that EFL teachers generally accept online teaching as a viable approach. The availability of online courses that can be accessed by students anywhere (whether in the classroom or at home) using various digital devices (such as computers, tablets, or mobile phones) is likely to be perceived as useful by teachers. However, EFL teachers faced challenges in the online teaching environment that were beyond their control, including issues such as unstable internet connections, physical separation from students, and the need to keep up with technological updates. These factors can significantly impact teachers' emotional expression during the online teaching process, which is supported in previous studies [8,13,18,66]. Therefore, it would be beneficial to address these challenges and improve the effectiveness of online instruction, which, in turn, can enhance teachers' positive emotions and avoid choosing surface acting. Resolving technology-related issues could play a crucial role in achieving these goals.

Secondly, concerning the overall profiles of EFL teachers' online teaching emotional labor strategies, an operational conceptualization of EFL teachers' online teaching emotional labor was initially presented, situated within the emotional experiences of EFL teachers in online teaching, and, for the first time, the dimensions of EFL teachers' online teaching emotional labor strategies were validated. It is noteworthy that this study contributes to the existing literature by responding to a call made by previous researchers [8,30,67] for the development of measurement tools for teachers' emotional labor and the exploration of variations in online teaching emotional labor strategies. Subsequently, the predominant types of online teaching emotional labor strategies employed by Chinese middle and high school EFL teachers are examined. The three-dimensional structure of online teaching emotional labor strategy consists of surface acting, deep acting, and expression of naturally felt emotions, which aligns with Yin's (2012) [30] three-dimensional framework of emotional labor strategies that includes surface acting, deep acting, and expression of naturally felt emotions. This structural division is also consistent with prior research indicating that the performance of emotional labor online involves a complex decision-making process influenced by factors such as teachers' teaching philosophy [14], their level of adaptation and acceptance of online teaching technology [13], the invisibility of the online teaching space, and the external environment surrounding the teachers' physical location [8]. Analysis of EFL teachers' scores on the three types of online teaching emotional labor strategy

reveals a higher inclination toward utilizing deep acting and expression of naturally felt emotions as strategies for regulating their emotions, while displaying a lesser preference for surface acting. Echoing prior research on teachers' emotional labor in the online teaching context [14], the present findings provide empirical evidence supporting the notion that teachers can experience, manage, and regulate their emotions while teaching online. Moreover, concerning emotional labor strategies, previous studies by Yin et al. (2017) [28] and Zhang and Zhu (2008) [68] revealed that Chinese teachers utilized surface acting less frequently. The current study aligns with their findings, indicating that EFL teachers are more inclined to engage in deep acting and expression of naturally felt emotions rather than surface acting. This tendency may be attributed to the fact that EFL teachers, in the process of online teaching, prioritize the effectiveness and satisfaction of online instruction. In line with specific online teaching contexts, they exert efforts to adjust their internal emotions using deep acting strategies to align them with their emotional expressions, thereby fulfilling the emotional demands of online education [8].

The preceding discussion emphasizes the effectiveness of employing deep acting and expressing naturally felt emotions as effective strategies for emotion management, irrespective of the instructional context, be it a traditional classroom or an online setting. Through engaging in deep acting, the majority of teachers were able to achieve congruence between their emotions and expressions. This is supported by insights gained from the interviews:

> "*As a teacher, I firmly believe it is inappropriate to bring negative emotions into the classroom, whether it is a physical classroom or an online environment. I am convinced that maintaining a positive attitude towards online teaching contributes to creating a better online learning experience, which, in turn, facilitates positive educational outcomes. When we speak with enthusiasm, students perceive us as more approachable, and this boosts their confidence in actively participating and responding to questions*" (T2)

Moreover, the participants in this study were more inclined to express their feelings using expression of naturally felt emotions than using deep acting and surface acting, which is consistent with the results reported in Yin et al.'s (2017) [28] study. In other words, EFL teachers were less likely to fake emotions that they did not truly experience through surface acting and instead showed a preference for expressing their authentic feelings. These findings also offer support for the arguments put forth by Benesch (2020) [29] and Loh and Liew (2016) [69] that the unique and contextually typical features of emotional labor in EFL teaching emerge due to factors such as neoliberal educational culture, the identity of language teachers, intercultural perspectives within English language disciplines, and the emphasis on bidirectional interaction between teachers and students in language instruction. This helps understand why EFL teachers tend to express genuine emotions in the teaching process. Moreover, the challenges posed by the invisibility of teacher behavior and emotions in the online space can affect the process of emotional labor engagement for teachers. In the absence of visual cues from students in the online environment, teachers face difficulties in gauging their students' emotional reactions, and consequently, they may need to employ additional strategies and invest more energy to ensure students' attention during the lesson [8]. Teachers may choose to directly express their dissatisfaction and anger with the hope of actively engaging students in the classroom. Another reason for preferring the expression of naturally felt emotions could be the belief that such emotions are more likely to encourage students and are easier for students to perceive. Furthermore, the invisibility of the online teaching space presents challenges for teachers to fake or suppress emotions during online instruction. This finding contradicts the research conducted by Wang and Song (2022) [8], who examined a group of 20 Chinese English teachers and found that teachers tend to suppress their emotions to ensure the effectiveness of online teaching. However, it aligns with the findings of Li and Liu (2021) [54], who investigated 484 Chinese beginning secondary school EFL teachers and found that teachers engage less in surface acting. Regardless of whether teachers suppress negative emotions or

feign positive emotions, mobilizing genuine positive emotions is more effective [31]. As expressed by teachers in the interview:

> "*In a traditional classroom setting, we have the capability to remind students who may be inattentive. However, in the context of online teaching, this option is not available to us. Consequently, our only recourse is to directly express frustration or anger, aiming to foster active engagement and serious participation from students in the online teaching process*" (T9)

> "*During the online teaching, I feel worried because I can't see the students' reactions or know if they understand what I teach. Sometimes, I even let the students know when I am angry. Being a teacher makes me feel a strong sense of responsibility, and I work hard to ensure that every student understands what I teach*" (T6)

> "*In the online learning environment, I believe that suppressing or pretending my emotions is not beneficial for both myself and the students. This is because we spend a considerable amount of time together, and it becomes challenging for me to consistently fake or suppress my emotions during our long-term relationship*" (T10)

Thirdly, the results demonstrated significant relationships between EFL teachers' acceptance of online teaching and the three types of online teaching emotional labor strategies (surface acting, deep acting, and expression of naturally felt emotions). Specifically, EFL teachers' acceptance of online teaching positively predicts their engagement in deep acting and expression of naturally felt emotions, while negatively predicting their involvement in surface acting. These results align with the initial expectations, indicating that EFL teachers' acceptance of online teaching significantly influences their adoption of different online teaching emotional labor strategies. This finding supports the key conclusions drawn from previous studies based on the TAM, which emphasize the critical role of instructors' acceptance of online teaching in shaping their attitudes, behaviors, and perceptions [7,70,71]. When teachers perceive online teaching as beneficial for their teaching outcomes, teachers' inclination towards a positive attitude and acceptance of online teaching can be enhanced [18]. Consequently, EFL teachers with a positive attitude towards online teaching are more likely to invest greater effort in utilizing educational technology for instruction. Conversely, resistance towards online teaching may result in a negative attitude, which can impact both the teachers' emotional experiences and behavioral tendencies during online instruction [13]. In addition, according to the investigation conducted by Jenßen et al. (2023) [72], there is a positive correlation between the integration of technology into teaching practices and teachers' professional expertise, as well as their affective-motivational dispositions encompassing emotions and self-efficacy. Wang and Song (2022) [8] argued that due to the influence of emotional norms associated with the target language culture and online teaching technologies, English teachers adopt different emotional labor strategies while engaging in online instruction. These findings provide additional support for the results of this study, and this is further corroborated by the interview data obtained from the teachers. Examples of responses are as follows:

> "*I have always been resistant to online teaching, as I believe it is not as effective as traditional teaching. I feel frustrated because I cannot observe the students' learning performance. However, I have to suppress my emotions and refrain from expressing my dissatisfaction to the students regarding the effectiveness of online live teaching. Instead, I need to convince the students to accept online learning*" (T7)

> "*Online teaching is convenient for both students and teachers. We can teach anytime and anywhere, as well as share teaching resources. It allows us to showcase a wide range of engaging and authentic online teaching materials related to language and culture, which is beneficial for language instruction. However, online teaching also has its drawbacks, such as the physical separation between teachers and students. Therefore, as teachers, we need to adjust our mindset and utilize every possible means to demonstrate genuine teaching emotions to students*" (T4)

The findings are in accordance with the findings of Davis (1989) [16], Venkatesh et al. (2003) [56], Nelson and Hawk (2020) [73], Sun and Zou (2022) [7], Zhu and Zhang (2022) [18] and Nguyen et al. (2023) [19], who suggested that TAM provides a robust and comprehensive explanation for behavioral intentions towards information systems. Among the observed variables of online teaching emotional labor strategies, EFL teachers' acceptance of online teaching primarily influences their emotional labor strategies through teachers' perceived usefulness of online teaching and perceived ease of use of digital technology. This finding provided empirical evidence for Wang and Song's research (2022) [8], which emphasized the importance of adaptation to online teaching technology for Chinese EFL teachers' online teaching emotional labor. As surface acting is positively correlated with emotional exhaustion [74], enhancing the ease of use and utility of online teaching platforms is crucial for facilitating greater engagement of teachers in deep acting and the expression of naturally felt emotions, which is beneficial to reducing teachers' emotional exhaustion.

7. Conclusions

This study attempted to examine the acceptance of online teaching, the emotional labor strategies employed in online teaching, and their relationship among Chinese EFL teachers. The findings demonstrate that EFL teachers generally had a positive acceptance of online teaching. The study supported the validation of three online teaching emotional labor strategies used by EFL teachers: SA, DA, and ENFE. Within the online teaching setting, DA and ENFE are the preferred online teaching emotional labor strategies for EFL teachers, while SA was employed to a lesser extent. EFL teachers' acceptance of online teaching significantly predicts three emotional labor strategies in online teaching. Specifically, EFL teachers' acceptance of online teaching positively influences DA and ENFE, while negatively affecting SA. By developing and testing a structural equation model to examine the relationship between EFL teachers' acceptance of online teaching and emotional labor in online learning environments, this study offers a new perspective for future research on EFL teachers' emotions and provides practical and pedagogical implications for achieving effective and sustainable online education, serving as a reference for future research concerning emotional labor in online teaching contexts. Firstly, it reveals that EFL teachers' positive attitudes regarding online instruction are an encouraging initial indicator that they are open to trying new methods in the classroom and making good use of technological advances in education. Since the participation and enthusiasm of instructors play a critical role in ensuring the effective implementation of online instruction mode, the positive implications of this are substantial for the sustainability of online instruction. Secondly, the validation of three emotional labor strategies (SA, DA, and ENFE) offers valuable support for the complex emotional landscape that teachers confront and highlights the importance of recognizing and understanding the emotional demands placed on EFL teachers in an online teaching setting. This insight can serve as a compass for teacher training programs, encouraging the integration of emotional management skills into their curricula to empower teachers in navigating the emotional difficulties of online teaching more effectively. Thirdly, EFL teachers' preference for DA and ENFE, along with the limited use of SA, underscores the importance of authenticity in online teaching. Promoting authenticity can foster stronger teacher–student connections, potentially lead to improved online learning outcomes, and guide educators to reduce insincere emotional displays in online teaching. Finally, it is noteworthy that the relationship between EFL teachers' acceptance of online teaching and their use of emotional labor strategies emphasizes the importance of promoting EFL teachers' positive attitudes towards online teaching. Enhancing teachers' acceptance of online teaching can result in better emotional management strategies and, possibly, enhance teaching and learning experiences. In conclusion, the study's findings shed light on the research on online teaching and emotional labor among EFL teachers. They stress the value of prioritizing the emotional well-being of EFL teachers while also improving the sustainability and effectiveness of online education.

8. Limitations and Future Research Directions

It is imperative to acknowledge the limitations inherent in this study, which also suggest directions for future research. Firstly, this study relied on self-reported questionnaires to collect EFL teachers' perceptions of the acceptance of online teaching and their online teaching emotional labor strategies, potentially ignoring their actual emotional labor behaviors. Thus, we suggest that future researchers devote more attention to teachers' online teaching processes by conducting action research and gathering more qualitative data (such as the observation of teachers' teaching behaviors and teachers' emotion journals) to provide more sufficient evidence for verifying the relationship between EFL teachers' acceptance of online teaching and their online teaching emotional labor strategies. Secondly, this study exclusively focused on EFL teachers' teaching practices within English online courses. Further investigations are warranted to assess if the findings and implications of the present study would apply to similar and dissimilar samples of subjects. Thirdly, an important insight from the technology acceptance model theory is that factors such as age, gender, proactiveness, and prior experience moderate relationships among the model's constructs [56]. This suggests potential avenues for future research to explore these aspects. In addition, teachers' acceptance of online teaching and emotional labor strategies are both crucial factors influencing teaching quality and student academic performance, but this study lacks the relevant exploration of these predictive factors, including their long-term effects and whether they contribute to enhancing teacher efficacy. These questions require more in-depth investigation in future research. Lastly, it would be worthwhile to explore whether there are temporal variations in the emotional labor strategies employed by teachers in online environments.

Author Contributions: Conceptualization, R.P.; Methodology, R.P. and Q.H.; Software, Q.H.; Validation, B.K.; Formal analysis, Q.H.; Investigation, Q.H.; Resources, Q.H.; Writing—original draft, Q.H.; Writing—review & editing, R.P. and B.K.; Visualization, B.K.; Supervision, R.P.; Project administration, R.P.; Funding acquisition, R.P. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Fundamental Research Funds for the Central Universities, HUST (Grant number: 2022WKYXZX002).

Institutional Review Board Statement: This study was conducted in accordance with all the required ethical considerations and practices. The study was approved by the Research Ethics Committee of the School of Foreign Languages, Huazhong University of Science and Technology (HUST).

Informed Consent Statement: Informed consent was gathered from all participating teachers. Confidentiality was maintained by not requesting names or any other information that would identify the participants involved and they were informed of their right to withdraw from the investigation at any time.

Data Availability Statement: Data will be made available on request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questions in the Interview

1. What do you think of teaching English in an online environment?
2. What are the primary challenges you face in online teaching?
3. What differences does online teaching bring compared to teaching in a physical classroom?
4. What efforts did you make to adapt to these differences, and did you experience any negative emotions during this adaptation process?
5. How do you manage your emotions before beginning an online class? Do you adjust your emotions before starting an online class?
6. What factors do you believe influence your emotional labor in online teaching?
7. How does online teaching impact your expression of emotions? Do you ever display faked emotions? Or suppress your emotions?

Appendix B.

Table A1. Dimensions, Items, Sources of Online Teaching Emotional Labor Strategies.

Dimensions	Item statements	Sources
Surface Acting	sa1. Despite feeling tired, I pretend I have energy.	[30,52,53]
	sa2. I artificially display enthusiasm, even if it does not genuinely reflect my inner state.	[30,52,53]
	sa3. When faced with network interruptions or technical malfunctions, I maintain composure despite feeling flustered.	Interview
	sa4. In conflicts with students, I suppress any feelings of displeasure.	Interview
	sa5. In cases of student misconduct, such as skipping classes, I restrain my own discontent.	Interview [52]
	sa6. Even in instances of copying homework, I do not show any internal displeasure.	Interview
	sa7. During online teaching, when students make mistakes, I fake anger.	Interview [52]
	sa8. When students fail to complete their assignments, I pretend to be deeply disappointed.	Interview [52]
Deep Acting	da1. When students' performance in online learning is unsatisfactory, I employ perspective-taking techniques to prevent anger from arising.	Interview
	da2. In cases of student mistakes, such as copying homework, I consciously calm myself and initiate a conversation with the student.	Interview
	da3. Even when facing resistance towards online teaching, I redirect my attention towards positive aspects as much as possible.	[11]
	da4. Despite any personal displeasure, I am able to maintain a joyful disposition while delivering my online classes.	[30,53]
	da5. When experiencing anxiety during online teaching, I make an effort to calm myself by appreciating the merits of online teaching.	Interview [54]
	da6. I actively strive to genuinely experience the positive emotions that I need to display while teaching online.	[30,53]
Expression of Naturally Felt Emotions	en1. When students make progress after online learning, it brings me a profound sense of gratification.	[11]
	en2. Positive feedback from students greatly boosts my confidence in online teaching.	Interview [52]
	en3. When students fail to pay attention in class, I openly express my disappointment.	[11,54]
	en4. When students actively participate and provide insightful answers, I feel a strong sense of accomplishment.	Interview [52]
	en5. When students are in a good state, it enhances my enthusiasm in online teaching.	Interview [52]
	en6. In cases where students lack engagement during class, I openly display my discontent.	[11,54]

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Presence and Flow as Moderators in XR-Based Sustainability Education

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Abstract: Virtual reality (VR) and augmented reality (AR) are emerging technologies with a variety of potential benefits for sustainability education. Here, learning processes such as flow and presence seem to determine the learning experience. Therefore, this paper presents the results of a mixed-methods study investigating a VR- and AR-based learning application on biodiversity developed by greenpeace. A total of 156 students tested the application addressing the Amazon rainforest and rated its efficacy in terms of effects on knowledge, interest, and attitude. Pre- and post-questionnaires as well as focus groups were used to uncover within-subject effects. The study results revealed that flow and presence had a moderating effect on knowledge and that this effect is strongest in learners with little prior knowledge. Presence also showed a moderating effect on one of three attitude measures. In general, the learning application was able to increase knowledge and improve attitude in this sample. The focus groups also revealed that the students engaged with environmental topics even after the experience. They also formed ideas for more environmentally friendly behavioral change. Moreover, the students described the application as impressive, captivating, and realistic. It can be concluded that presence and flow are crucial processes for learning with VR and AR technologies.

Keywords: virtual reality; augmented reality; xReality; sustainability education; biodiversity; sustainable development; presence; flow

Citation: Mulders, M.; Träg, K.H. Presence and Flow as Moderators in XR-Based Sustainability Education. *Sustainability* **2023**, *15*, 16496. https://doi.org/10.3390/su152316496

Academic Editors: Rustam Shadiev, Barry Lee Reynolds and Rui Li

Received: 29 September 2023
Revised: 28 November 2023
Accepted: 29 November 2023
Published: 1 December 2023

1. Introduction

Virtual and augmented reality (VR/AR) technologies have increasingly gained attention in educational settings over the recent years. They are expected to be widely used in classrooms, but investigation of their educational potential has only just begun [1–3]. However, the nomenclature surrounding VR and AR technologies is somewhat disputed. On one hand, VR and AR could be viewed as end points on the same spectrum, where the distinguishing feature is the degree of immersion [4]. On the other hand, AR and VR could be construed as two different qualities of experience, where AR applications address a form of physical presence augmented by virtual features while VR aims at a form of telepresence, or feeling present within the virtual space [5]. Hence, Rauschnabel et al. [5] use the umbrella term xReality or XR to describe both AR and VR technologies, where the X denotes a placeholder. Here, it is not appropriate to equate XR with extended reality [6]. In this paper, the term XR will be utilized to describe an application that incorporates both AR and VR elements.

The learning application investigated in this study is called On Biodiversity's Tracks. It is a virtual XR environment developed by greenpeace, a non-profit organization that is active in the field of environmentalism. It allows students to visit places like the Great Barrier Reef or the Amazon rainforest to learn about the people, animals, and environment there. The goal of the greenpeace XR application is to foster knowledge on environmental sustainability and biodiversity while also increasing students' interest and possibly leading to a more positive attitude towards the environment and sustainable behavior [7]. The general effectiveness of the XR application concerning knowledge, interest, and attitude

is reported in another paper [8]. This paper focuses on examining the learning processes that occur during the exploration of the application (e.g., experiencing presence in a virtual world) and their moderating effects. A mixed-methods approach is implemented to make use of the advantages of both quantitative and qualitative data analysis. Overall, this study serves to deepen our understanding of how the learning processes of presence and flow that take place when learning with XR, affect knowledge, interest, and attitude, all while evaluating a ready-made XR application for classroom use. This is important because educational XR applications, especially those in the German language, are relatively sparse [9].

2. Literature Review

2.1. Classification of VR/AR Technology

VR is understood as a computer-generated simulation that is three-dimensional (3D), multisensory, and interactive. The user can inhabit and act within an external environment [10,11]. VR enables unique learning scenarios, as simulations allow students to act as if they were in a real environment while interacting with otherwise intangible or inaccessible objects [12,13]. VR provides users with the experience of a different world that may otherwise be too dangerous, expensive, or impossible in the real world [14,15]. AR, in contrast, is used to enhance and enrich the real-world learning experience. It involves overlaying digital information, such as images, videos, 3D models, or text, onto the real-world environment to provide users with additional context, interactivity, and engagement [16].

In everyday language, the terms VR and AR are often used as umbrella-terms including a variety of heterogenous technologies [17,18]. Thus, VR and AR are presented to users through different technological approaches and devices, each offering distinct experiences. Whereas head-mounted displays (HMDs) completely immerse users in a computer-generated virtual world by covering their field of vision with screens [19], mobile devices' cameras are commonly used for AR learning scenarios by embedding digital content into the real world [20]. Further technologies are also utilized, for example HoloLens for AR, and various mobile devices (e.g., tablets) for VR. It has been demonstrated that many researchers face challenges when categorizing the technology they utilize. In many cases, a distinction is also made between immersive technologies (e.g., HMDs) and non-immersive technologies (e.g., tablets). However, often, a single technology combines features of both AR and VR [1], as is the case for the application investigated in the present study. Rauschnabel et al. provide a suitable alternative by introducing the term XR, with the X serving as a placeholder [5]. In this context, XR is not to be equated with extended reality [6,21] but is rather used in this paper to denote a single application comprising multiple VR and AR elements.

2.2. Learning with VR/AR

VR and AR technologies are considered to have great potential for designing teaching and learning scenarios. They open a range of multifaceted applications for schools, universities, and other educational institutions [1–3,22]. The Cognitive Affective Model of Immersive Learning (CAMIL) addresses two facets of immersion that improve learning through XR technology: agency and presence [23]. A higher degree of interactivity as well as the feeling of actually being in the virtual environment and interacting with seemingly real social agents are beneficial for the learning process, especially for procedural learning [23,24].

In recent years, there has been increasing effort to make use of the multiple possibilities of VR and AR to enhance and diversify learning processes in educational settings. In this context, the unique characteristics of VR and AR have been associated with several learning affordances such as improved spatial knowledge representation, enhanced empathy, increased motivation and student engagement, higher contextualization of learning, and experiential learning scenarios [14,25]. Thus, VR and AR are particularly relevant for learning content that cannot easily be studied in a traditional classroom setting [26,27], such

as exploring the universe and planetary constellations or visiting the Amazon rainforest, which is investigated in this study.

Recently, VR and AR technologies are increasingly being used for environmental subjects, i.e., climate change or biodiversity loss, as a tool to inform and engage the public with current and future environmental issues [28,29]. The potential to influence the affective experience through VR or AR appears promising. According to Mayer and Frantz [30], a feeling of connectedness to nature leads to a stronger concern for nature and can invoke tangible actions such as pro-environmental behavior. VR and AR technologies can indeed evoke such feelings of connectedness. They offer increasing engagement and provide interactive, action-oriented, affective, and empathetic experiences [16]. Individuals can take on someone else's perspective, get interactively involved, see consequences, foresee future climate change scenarios, and experience sensory stimulations that can have a strong impact on affections [31]. However, there are still only limited numbers of VR and AR learning applications dealing with sustainability topics. Valid research results for the use of these applications in the various fields of the Sustainable Development Goals (SDGs) are still in early stages [32].

2.3. Determinants of VR/AR Learning

With VR and AR technologies becoming increasingly prevalent and popular in classroom use—outside of sustainability education—several determinants of successful learning in VR and AR have already been examined. Ease of use seems to be one relevant factor, since many students find VR and AR technologies difficult to use [33,34]. Prior experiences with the technology and amount of practice also influence learning outcomes [35]. With these determining factors set, finding more relevant correlating variables could enhance our understanding of VR and AR learning even further. Specifically, exploring moderating factors could help explain how the affording mechanisms of technology, agency, and presence [23] influence learning.

Multiple previous studies present possible moderators. Johnson–Glenberg et al. [36] outline embodiment, collaboration, presence, and possibly novelty as key contributing factors. In addition, the experience of flow seems to be correlated with the success of a VR learning activity [37,38]. According to Zhang et al. [35], discipline plays an additional role, with overall large effect sizes for science, language, and health and medicine, and insignificant effect sizes for engineering. In that study, grade level, input as well as output devices, and pedagogy and instructional function did not play a role as moderators. In contrast, usability seems to be another relevant factor for feeling present in VR and AR applications [39]. In addition, it should be noted that contextual variables (e.g., the prior knowledge, prior interest, and prior attitude of users) may also have an influence on the learning outcomes [40].

2.4. Experiencing Presence and Flow in VR/AR

Presence has frequently been named as one of the underlying affordances of VR and AR technologies [23,40–42]. It is often understood as the feeling of being there, captured in three dimensions: Social presence describes the feeling of interacting with actual people, or with digital agents seeming real [43,44]. Physical presence refers to the sensation of being spatially inside the virtual environment, whereas self-presence refers to the feeling of being represented or the avatar feeling representative of oneself inside the virtual landscape [43,44]. Typically, 3D applications are associated with higher physical and social presence than 2D environments, while physical presence is frequently perceived stronger than social presence [45,46]. Given that the greenpeace XR application does not use player avatars, self-presence will not be examined further in this paper.

Generally, some research results suggest that presence influences learning in virtual environments. However, opposite research findings are detectable. Whereas some results indicate that the experience of presence has a positive effect on the learning outcomes to the extent that a higher level of presence experience requires a stronger focus of attention

on learning-relevant stimuli [47,48], Makransky et al. [49] found a negative correlation between learning and presence experience. The authors concluded that higher presence could lead to distraction by many irrelevant details or high arousal.

Flow experience has also been associated with VR and AR learning technologies [50]. Flow is often characterized by perceiving an activity as highly satisfying, with a minimal or even complete absence of a sense of separation between the individual and the activity itself [51]. During such experiences, the actions become almost automated, leading to more efficient and faster performance. Another notable aspect of the flow state is the subjective loss of awareness of time passing [50]. Rheinberg and colleagues have conceptualized flow as a multidimensional construct, consisting of two key facets: absorbedness and smooth automated progression. The former represents complete engagement in an activity, while the latter refers to the seamless flow of consecutive actions [52].

In general, there remains a limited body of empirical research on the relationship between flow experiences in VR and AR and various learning parameters. The present study aims to contribute to the understanding of this relationship.

In game-based learning, engagement was linked to presence and flow, and had a positive effect on learning [53]. Kye and Kim [54] also found that presence and flow positively impact student satisfaction and learning outcomes. Likewise, in a game-based study, Janssen et al. [55] assumed that greater feelings of presence in VR leads to better user experiences and affords student interaction with the virtual environment. In their exploratory experiment, flow correlated positively with presence.

Overall, presence and flow seem to be related to a positive game experience, and by extension, to better task performance [55].

Our literature review found that utilizing VR and AR technology in learning environments usually increases learning achievement [33,34,56,57]. However, within this paper, we do not aim to investigate the effectiveness of the XR learning application itself. Rather, we seek to understand the underlying mechanisms. The literature suggests that certain characteristics of VR and AR lead to a stronger perception of presence and flow, which in turn influences learning outcomes. Therefore, this study attempts to explore determinants of learning using an XR learning application focused on sustainability topics (i.e., biodiversity in the Amazon rainforest).

3. Hypotheses and Key Questions

There is a growing body of research suggesting that basic comparisons between different types of media are neither methodologically nor substantially sound. Buchner and Kerres [58] as well as Mulders [40] pointed out that bare media comparisons between experimental and control groups neglect pedagogical idiosyncrasies of each of the respective mediums. Apart from that, the comparability of different media that provide different affordances is generally questionable [40]. For these reasons, the present study aims at expanding the common media comparison model by illuminating the mechanisms behind the effects. Specifically, flow and presence are being investigated as possible moderators [39,54,55] affecting change in knowledge, interest, and attitude [14,23,41]. To examine these effects, data were obtained from both a quantitative and a qualitative study.

We quantitatively examine the moderating effects of flow (Hypotheses 1) and presence (Hypotheses 2) on learning outcomes and test the following assumptions:

H1a. *A higher perception of flow positively influences knowledge gained.*

H1b. *A higher perception of flow positively influences interest gained.*

H1c. *A higher perception of flow positively influences attitude improved.*

H2a. *A higher perception of presence positively influences knowledge gained.*

H2b. *A higher perception of presence positively influences interest gained.*

H2c. *A higher perception of presence positively influences attitude improved*.

In these instances, knowledge is to be understood as the self-ascribed degree of declarative knowledge on the subject. Interest describes interest elicited by the presented topic, or topic interest [59]. Attitude is defined as the degree to which a person finds a psychological object favorable or unfavorable [60].

In addition to hypotheses testing, we will delve deeper into the relationships between flow, presence, and potential additional moderators through a qualitative investigation. We will examine the following key questions:

Q1: To what degree did the students perceive long-term effects regarding their knowledge on, interest in, and attitude towards the Amazon rainforest?

Q2: Which cognitive and/or affective processes did the students experience while learning with the XR application?

4. Materials and Methods

4.1. The Greenpeace XR Application

The greenpeace XR learning application On Biodiversity's Tracks was developed by greenpeace, a transnational non-profit organization whose goals include environmental and climate protection. The application was developed for several mobile devices and has not yet been evaluated scientifically. It is a web-based solution, meaning students do not need to download the application and give up personal data, and is accompanied by Supplementary Materials providing technical and instructional guidance. The application is designed for supervised use in classrooms for students in grades seven to nine. Its purpose is to convey knowledge and emphasize the importance of SDGs. After scanning a QR code with a mobile device (e.g., tablet), students can virtually travel to various locations around the globe, which would have been challenging to experience in a typical classroom setting. The app consists of a combination of AR and VR elements. At the beginning, reality is augmented through the camera lens of the mobile device with a 3D model of a globe, which is used to pick a destination. Subsequently, these travel destinations (e.g., Great Barrier Reef, Amazon rainforest) are exclusively presented virtually on the screens of the devices. This study primarily focuses on one of the travel destinations of the greenpeace XR application, namely the virtual representation of the Amazon rainforest. This virtual world is characterized by auditory elements (e.g., rainforest sounds) and visual content (e.g., intact vs. non-intact rainforest) and can be freely explored by students. Information about the rainforest's reality is integrated within the environment. Various interactions with virtual agents (e.g., native animals such as ants) are possible. Figure 1 provides an overview.

4.2. Design and Participants

Our mixed-methods study examined the influence of the greenpeace XR application on its ability to foster students' knowledge, interest, and attitude regarding sustainability and biodiversity. Special attention has been paid to presence and flow as moderating factors.

The greenpeace XR application was used in a standard lesson at eight German secondary education facilities. For the quantitative part of the study, online questionnaires were administered directly before and after the lesson. For the qualitative portion, focus groups with students were conducted, to gain insight into their experiences during the XR application use.

Teachers as well as parents and students received information about the experiment, giving parents the option to opt their children out of the study. Datasets of 274 students were usable. Out of those, 159 completed the experimental XR condition. After checking for outliers, three participants were determined to have used patterns for answering their posttest questionnaires and were removed, leaving a final sample of 156 participants. Students were roughly 13 years old on average (M = 13.30; SD = 1.02). Over half identified as male (61.3%), with 37.4% identifying as female and 1.3% identifying as non-binary. One of the participating schools was an all-boys school, leading to a higher proportion of male

students in this sample. For the eight focus groups, a total of 84 out of the 156 students participated. Group size varied widely between 2 participants for the smallest and 25 for the largest group (M = 10.5, Md = 9). While the quantitative portion of this study was conducted during and as a part of the regularly scheduled classes, the focus groups were opt-in and (depending on the school) had to take place outside of regular lessons, leading to lower participation and a higher deviation in group sizes.

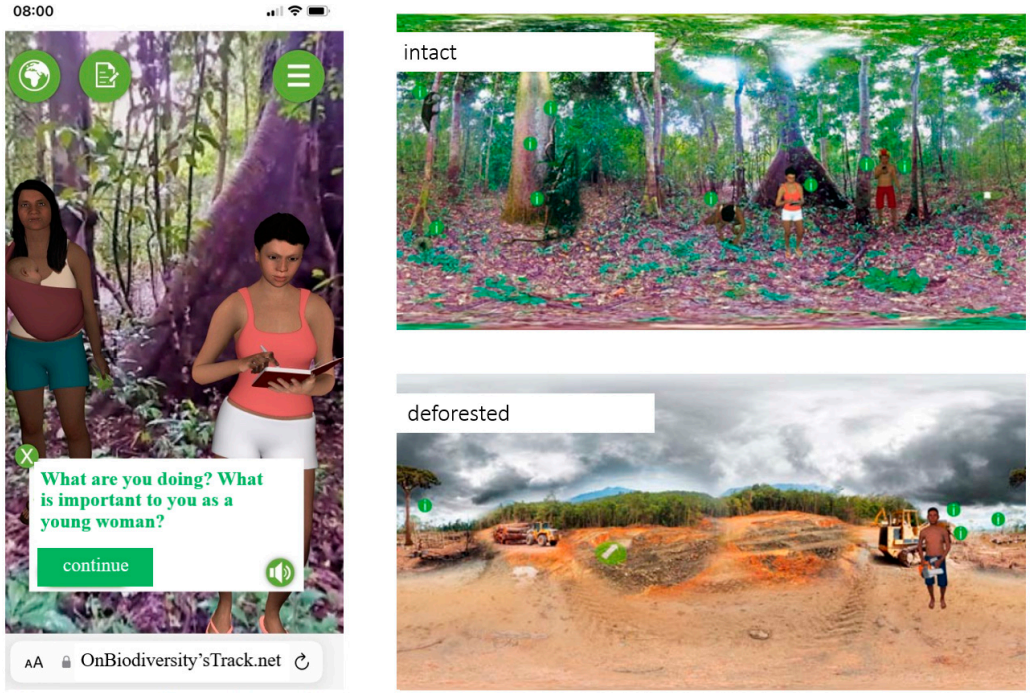

Figure 1. The greenpeace XR application: (**a**) communication with locals; (**b**) views of the rainforest.

4.3. Procedure

After receiving confirmation from eight secondary schools in Germany, detailed information about the study was sent to the teachers and parents of the students in January 2023 requesting their parental agreement (see Supplementary Materials). Subsequently, teachers started implementing the greenpeace XR application no longer than two weeks after a briefing on 15 February 2023. Participation in the study was voluntary for the students. During the lesson (held in the 90 min time slots that are standard in German secondary schools), teachers introduced the lesson on the topic of sustainable development before the students tested the application on their own mobile devices with a focus on the Amazon rainforest topic. Before and after exploring the app, the students individually filled out online questionnaires. The questionnaires were created using Sosci Survey. The anonymity of the students was ensured through participant codes, and the data cannot be traced back to individual students. At the end of the lesson, the students discussed the experience under the guidance of their teacher. Within two weeks after the lessons, students from the sample who volunteered to participate in the focus groups were sent a link to an online meeting via Zoom. Students were greeted by a moderator and two transcribers. Teachers were absent. The focus groups did not exceed 60 min in duration. The focus groups followed an interview guide tailored to the key questions and were divided into blocks (e.g., experiencing presence). Each focus group was visually supported through a miro board. A screenshot of the miro board slides can be found in the Supplementary Materials online. The final interview was conducted on 27 March 2023. The audios of the focus groups were recorded; transcripts without the names of the students, schools, etc., were created; and subsequently, the audio files were deleted. The qualitative data material was examined

according to the focused content analysis [61,62]. To form categories, we used a mixed form of inductive–deductive coding. Based on our hypotheses, we pre-formed categories for flow and presence and further divided them into subcategories according to their facets (e.g., physical presence). The interview guide was aligned with these pre-formed categories but also included many open-ended questions. New categories and subcategories were derived from the responses to the open-ended questions. Subsequently, the frequencies of categories and the relations to one another were analyzed. The qualitative data material was coded by a project team member, frequencies were counted, and quotes were extracted. The project leader coded the same material randomly to ensure data reliability. The analysis of qualitative data, based on derived categories and quotations, is intended to provide initial insights into how the two key questions can be answered.

4.4. Instruments

The online questionnaire was developed by the project team. Where possible, we used already validated questionnaires. Preliminary versions of the questionnaires were tested with seven students. Following that, some of the items were adapted for legibility and easier-to-understand language. In total, the pre- and the post- questionnaire included one item for self-appraised knowledge ("How substantial would you rate your knowledge on the Amazon rainforest?"), two items for interest (e.g., "To what degree are you interested in the Amazon rainforest?") and three items for general attitudes towards the development in the Amazon rainforest (e.g., "To what degree do you think that the situation in the Amazon rainforest affects us and our environment in Europe?"). Since these are newly formulated items by us, we checked their validity in several discussions with experts from greenpeace and asked the seven students who tested the preliminary version how they understood the items. Minor linguistic adjustments were made. To further assess attitude, the six items of the Green Scale [63,64] (e.g., "My purchase habits are affected by my concern for our environment.") as well as the ten items of the scale for Common Attitudes Towards Environmental Protection and Sustainable Development (Environmental Protection Scale, EPS, [65,66]; e.g., "I am concerned when I think about the environmental and social conditions under which we and future generations will likely have to live.") were included. Flow was measured with the ten Flow Short Scale (FSS) items [67,68] (e.g., "I had no difficulty concentrating."). Sense of presence was measured with a translation [46] of the physical presence (e.g., "The virtual environment seemed real to me.") and social presence (e.g., "I had a sense that I was interacting with other people in the virtual environment, rather than a computer simulation.") subscales (five items each) of the Multimodal Presence Scale (MPS, [69]). Knowledge, green consumer values, environmental protection attitude, and presence were measured on 5-point Likert-scales, while interest, general attitude, and flow were measured on 7-point Likert-scales. Furthermore, demographic data (here gender and age) of the students were collected. For the quantitative data analysis, a Python [70] script was created for data cleaning, while the data analysis was conducted in R version 4.2.2 [71], specifically using parts of the R packages car [72], careless [73], DescTools [74], interactions [75], lsr [76], moments [77], and psych [78].

For the focus groups, methodology was shifted from a quantitative to more of a qualitative approach. Students were asked about their opinions on and perception of learning through the XR application. Interviewers roughly followed manuals that included questions on knowledge retention, interest, attitudes, and sense of presence.

All questionnaires as well as the manual for the teachers and an interview guide for the focus groups can be found in the Supplementary Materials online.

5. Results

5.1. Quantitative Data Analysis

The presentation of the statistical analyses of the data from the online questionnaires is divided into three main sections. First, descriptive statistics are reported. This includes internal consistencies, means, standard deviations, and missing values of the items or

scales. Before the moderating effects of the learning process variables are inferentially tested, Pearson correlations between the learning processes and the learning objectives are provided in the second section. Finally, several moderator analyses testing hypotheses one and two can be found in the third section.

5.1.1. Descriptive Statistics

Table 1 shows overall good reliability for the moderator scales, with Cronbach's α consistently above 0.80 [79]. In Table 2 means, standard deviations, and missing values for all key variables are presented. There were slight increases in knowledge and general attitude from the pre- to the post- measurement point, whereas interest, green consumer values and attitudes toward environmental protection remained roughly the same. Values for the Green Scale and EPS were considerably lower than they were for the norm samples in their respective studies [63,66]. For the Green Scale, this might be due to the comparably younger age of the students in the present study, where consumer values are possibly not as developed yet. Meanwhile, the original sample for the EPS consisted of teachers, who are generally considered very environmentally conscious [66]. Flow among the students in the present study was comparable to mid-lecture students in the norm sample [67]. Social presence was comparable to the German language norm sample, while physical presence seemed lower in the present sample [46]. Lower social than physical presence is congruent with previous findings [45].

Table 1. Internal consistencies.

Scale	Cronbach's α
Flow Short Scale	0.92
Multimodal Presence Scale	0.92
Multimodal Presence Scale—physical	0.85
Multimodal Presence Scale—social	0.88

Table 2. Means, standard deviations, and missing values of all key variables.

Pretest	M	SD	NA	Posttest	M	SD	NA
K *	3.06	0.81	0		3.37	0.85	25
I *	4.58	1.29	0		4.60	1.43	28
A *	5.00	1.26	1		5.26	1.35	42
G *	3.24	0.69	0		3.29	0.81	43
E *	3.57	0.58	0		3.58	0.68	45
Flow	X	X	X		4.31	1.23	46
MPS *	X	X	X		2.75	0.83	45
MPS ph *	X	X	X		2.80	0.83	45
MPS so *	X	X	X		2.72	0.89	46

* K—knowledge, I—interest, A—attitude, G—Green Scale, E—Environmental Protection Scale, MPS—Multimodal Presence Scale (ph—physical subscale, so—social subscale). Skewness and kurtosis measures are provided in the Supplementary Materials.

5.1.2. Correlations

To check the prerequisite for moderator analysis of low multicollinearity and to gauge whether the assumptions stated above are plausible, Pearson correlations between all key variables were computed (see Table 3). No correlation above 0.80 was detected. Therefore, lack of multicollinearity can be assumed [80]. The pretest scores of all learning indicators generally showed medium to high correlations with their respective posttest scores. Flow correlated highly with presence. Upon further investigation, this correlation was significant, $r = 0.565$, $p < 0.001$. Correlations between flow, presence, and the difference between pretest and posttest scores were calculated. Table 4 shows significant correlations between flow and gain (as in, the difference between pre- and posttest) in every variable except for general

attitude, which was not statistically significant. Regarding presence, the only significant correlation was found for change in knowledge.

Table 3. Correlations between the key variables.

	Pretest					**Posttest**					
Pretest	**K**	**I**	**A**	**G**	**E**	**K**	**I**	**A**	**G**	**E**	**Flow**
K *	1										
I *	0.38	1									
A *	0.22	0.43	1								
G *	−0.01	0.43	0.36	1							
E *	0.12	0.38	0.45	0.57	1						
Posttest											
K	0.38	0.33	0.20	0.13	0.30	1					
I	0.20	0.57	0.37	0.45	0.48	0.45	1				
A	0.18	0.28	0.58	0.42	0.57	0.23	0.44	1			
G	0.04	0.29	0.32	0.76	0.59	0.24	0.43	0.52	1		
E	−0.07	0.26	0.39	0.55	0.76	0.20	0.42	0.57	0.73	1	
Flow	0.13	0.28	0.28	0.40	0.34	0.34	0.47	0.39	0.55	0.42	1
MPS	−0.03	0.17	−0.03	0.30	0.11	0.17	0.20	0.01	0.38	0.10	0.58

* K—knowledge, I—interest, A—attitude, G—Green Scale, E—Environmental Protection Scale, MPS—Multimodal Presence Scale.

Table 4. Correlations between flow, presence, and gain in knowledge, interest, general attitude, Green Scale attitude, and Environmental Protection attitude.

		K *	**I ***	**A ***	**G ***	**E ***
Flow	*r*	0.214	0.241	0.164	0.276	0.197
	p	0.026	0.011	0.092	0.004	0.042
Presence	*r*	0.194	0.058	0.028	0.101	−0.001
	p	0.043	0.545	0.772	0.297	0.989

* K—knowledge, I—interest, A—attitude, G—Green Scale, E—Environmental Protection Scale.

5.1.3. Moderator Analyses

Other prerequisites for moderations analysis were also assessed. A Shapiro–Wilk test revealed no relevant deviation from normal distribution regarding error terms (see Supplementary Materials). Graphical analyses showed homoscedasticity for all dependent variables. Assuming linear regression, ten interaction models were proposed, where flow or presence moderate the relationship between a variable's pretest and posttest score, i.e., flow moderating the relationship between pretest knowledge and posttest knowledge. Table 5 shows that all ten moderator models significantly explain variance in the dependent variable However, the interaction between the independent variable and the moderator is only significant in three cases: knowledge–flow, knowledge–presence, and EPS–presence. Pretest interest ($t = 3.92$, $p < 0.001$) and presence ($t = 2.24$, $p = 0.027$) as well as pretest general attitude ($t = 3.57$, $p < 0.001$) and flow ($t = 2.15$, $p = 0.034$) influence the posttest value in their respective models independently, without an interaction. For general attitude and the Green Scale, only the pretest score and not presence affected the dependent variable. The same is true for flow on the Green Scale and EPS. The interest–flow model showed no effect at all.

Figure 2 shows the interaction of flow and presence with knowledge, the only variable with which both moderators interacted. For both flow (Figure 2a) and presence (Figure 2b), the following applies: The higher the pretest knowledge, the less relevant were the moderating effects. Conversely, this means that flow and presence have a stronger moderating effect for individuals with little prior knowledge.

Table 5. Moderator analyses.

	Model			Interaction	
	F (df)	***p***	**R^2**	**t**	***p***
K *: Flow	13.00 (3, 104)	<0.001	0.252	−2.19	0.031
I *: Flow	26.43 (3, 106)	<0.001	0.412	0.41	0.682
A *: Flow	25.09 (3, 103)	<0.001	0.405	−1.53	0.128
G *: Flow	56.76 (3, 104)	<0.001	0.610	−0.59	0.557
E *: Flow	53.49 (3, 103)	<0.001	0.598	−0.37	0.711
K: Presence	10.10 (3, 105)	<0.001	0.202	−2.19	0.031
I: Presence	18.75 (3, 107)	<0.001	0.326	−1.87	0.064
A: Presence	19.69 (3, 104)	<0.001	0.344	−0.47	0.641
G: Presence	44.93 (3, 105)	<0.001	0.550	−0.65	0.515
E: Presence	52.39 (3, 104)	<0.001	0.590	−2.56	0.012

* K—knowledge, I—interest, A—attitude, G—Green Scale, E—Environmental Protection Scale, R^2—adjusted R^2.

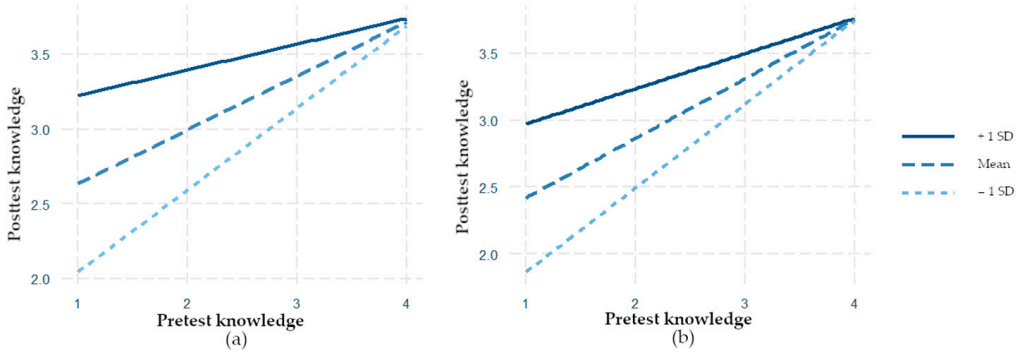

Figure 2. Interaction between (**a**) flow and knowledge and (**b**) presence and knowledge.

Regarding our hypotheses, based on the moderator analyses, it can be stated that these results support Hypothesis 1a (higher perception of flow positively influences knowledge gained), while Hypotheses 1b (higher perception of flow positively influences interest gained) and 1c (higher perception of flow positively influences attitude improved) are not supported. It should, however, be noted that we found significant correlations between flow and interest gain as well as between flow and gain in two of the three attitude measures.

Similarly, Hypothesis 2a (higher perception of presence positively influences knowledge gained) is supported by these findings. Hypothesis 2b (higher perception of presence positively influences interest gained) is not supported. Hypothesis 2c (higher perception of presence positively influences attitude improved) can only be partially supported, since a moderation effect could only be found for one of the three attitude measures, namely the EPS.

5.2. Qualitative Data Analysis

In addition to the quantitative data, qualitative data were collected during the focus groups. This provided us with a deeper insight into the students' lsearning experiences. Further, it allowed us to identify additional learning-related factors beyond the moderating effects of flow and presence that we initially assumed. An exhaustive analysis of the qualitative data can be found in another paper [81]. A selection of relevant results will be presented in the following two sections along with the two key questions. Categories and the number of focus groups that mentioned each respective category (*N*) will be reported. There were eight focus groups in total, resulting in a maximum mention of eight.

5.2.1. Key Question 1: Learning Effects

Most of the focus groups reported that the XR application was informative and that they have learned a lot (e.g., deforestation (*N* = 6), structure of an anthill (*N* = 2)). However, the students said they were already interested in environmental topics before, but that

the XR application provided the opportunity to travel to distant places and experience firsthand the threat of climate change to animal and human species. They described that the application had emotionally impacted them, and they had to think a lot about it. For example, a student from focus group 8 expressed: "[...] You always hear a bit about it in the news, what's going on, but now through last week, where we could experience the changes in the rainforest up close ourselves, you think a lot more about it than you did before [...]."

Across all groups, it was reported that the students extensively reflected on the virtual experience in the one or two weeks following. Many students recognized the relevance of environmental protection for their own lives and those of future generations (N = 5). These reflective processes seem to persist and remain a topic of discussion within the respective classes. The engagement with the experience occurred individually, among peers, within families, and at school. Many of the students seem to have developed an awareness of environmental issues during this post-experience period. They began to form initial ideas on how they, their friends, families, and their schools can contribute to environmental protection over an extended period (N = 4). Among these ideas are (1) the purchase of sustainable food items, (2) reduction of plastic items, (3) avoidance of palm oil, and (4) reduction of printed materials in school. In summary, the XR application seems to have triggered something in the students on an affective level, especially in the days following the virtual experience. It appears that the primary focus is not so much on the increase in knowledge or heightened interest, but rather on initial changes at the level of attitudes and behaviors, similar to previous findings [82].

5.2.2. Key Question 2: Cognitive and Affective Processes

The students were asked to describe the cognitive and affective processes that took place during the virtual experience. Within the focus groups, the students reported that they felt focused, captured, and motivated while using the XR application. Additionally, they perceived the application as exciting and realistic. Learning was enjoyable for them. Furthermore, they reported that they gained a "better impression" (focus group 6) of the rainforest and the life on-site, allowing them to easily empathize with the local circumstances. One student describes it as follows: "Because you could experience it directly in the virtual world, and you could almost sneak in and feel the life, just like they actually feel there." (focus group 4). This is somewhat in accordance with another study, where nursing students, while a major point of criticism was a lack of realism, also lauded a high degree of interactivity in the VR application used [83].

Considering the statements from all focus groups, three processes can be identified that made learning with the greenpeace XR application unique and special for all students: (1) authentic audio–visual stimulation, (2) interactions with virtual actors, and (3) physical and social presence experiences. It is noteworthy that while presence or a description of the feeling of presence were mentioned multiple times by the students, the term flow and its synonyms were not named. However, the three processes listed above were increasingly associated with the assessment of the XR learning application. When students reported on processes that occurred during their learning, an evaluation of the application often followed directly or in close temporal proximity (i.e., within two sentences). This is how one of the students attempts to summarize the experience: "[...] I think it stayed better in my memory. [...] I was apparently really on-site and could understand the life of animals and people in the Amazon rainforest more easily. [...] Even now, when I think about it, I still have all the images in my mind. For example, with the deforestation, how the boy was standing there and the single tree with the bulldozer and all that [...]" (focus group 6).

6. Discussion

6.1. Interpretation of Results

The results of the mixed-methods study reveal several implications. First, both data sets, qualitative and quantitative, showed that the greenpeace XR application can impart knowledge about biodiversity and influence environmentally relevant attitudes of the

students. However, while the quantitative data revealed only few differences from the pre to post measurement points (e.g., knowledge, general attitude), students in the subsequent focus groups reported more on attitude and even behavior changes (albeit mainly for change in individual behavior as opposed to systemic change). This can be interpreted as the students not having sufficiently processed the content shortly after the lesson and using the days leading up to the focus groups to reflect on these contents alone or with others. The lack of change in interest may be explained by the students stating that they were already very interested in environmental issues before the lesson, making a further increase unlikely.

Second, correlation analyses showed several significant relationships between flow, presence, and the differences between pretest and posttest scores, congruent with a large corpus of previous research [33,34,54–57]. Many of the learning gains are particularly associated with flow. The subsequent moderator analyses revealed only a few significant interactions. The interaction of flow and presence with knowledge appears especially interesting. For both flow and presence, higher pretest knowledge seems to mitigate the effect of the moderator. In turn, this implies that flow and presence exert a more significant moderating effect on individuals with little prior knowledge.

Third, qualitative data revealed a strong relationship between learning processes (e.g., presence) and the evaluation of the application. This finding indicates optimization potential for developers. By promoting the experience of flow, presence, audio–visual stimulation, and interactions with virtual actors, the learning experience can be made more engaging to students, thus supporting learning in general. Overall, this seems to be in line with previous findings. Bodzin et al. [37] found that experiencing flow in an immersive VR game is linked to positive attitudes towards learning with VR. Focus groups also mentioned a sense of presence and interactivity as contributing factors for enjoyment, and that this form of presentation provides new perspectives [37]. Another study found that flow and presence enhanced satisfaction in VR [40]. However, those studies did not report effects on knowledge-based learning outcomes, as opposed to Tai et al., where flow predicted both the procedural accuracy and executive quality of car detailing [38]. Comparability to the present study might, however, be somewhat limited, considering that those are both procedural learning outcomes.

6.2. Implications

The present results partially corroborate the assumptions of the theoretical frameworks that propose presence and flow as background processes during learning with XR technologies [23,50,51]. However, the link between flow, presence, and some of the learning outcomes, especially interest and some attitude measures, seems somewhat weak. This might be due to the methodological limitations of the present study, which will be discussed in the following chapter. Future research could look into more complex models that incorporate flow and presence. For example, serial mechanisms between presence and flow could be investigated. A hypothesis worth exploring could be that experiencing presence is a necessary condition for experiencing flow in virtual environments.

The lack of findings regarding interest impedes drawing theoretical conclusions. Results do however support the notion that attitude, and behavior are inherently linked [60]. Students' statements from the focus group show a somewhat clear timeline were willingness to change their own behavior follows the intervention after phases of reflection and attitudinal change. It can be concluded that the app alone is unlikely to generate significant changes at the level of attitudes and behavior. Teachers using the app in the classroom must create reflective activities that allow students to relate the content to their own real-life experiences. Based on the positive correlations between flow, presence, and learning outcomes we found in our study, it seems advisable for teachers to look back on the feelings of the students when they used the app. These feelings seem to persist in the minds of the students, as the focus groups revealed. Therefore, if a teacher connects to the feelings experienced in the virtual space during subsequent reflection, it may be possible

to generate sustainable changes at the level of attitudes and behavior. This assumption should be tested in follow-up investigations.

6.3. Limitations

The present study is limited by its design. Regarding the quantitative part of our study, an adequate control group is missing. The comparison to a control group that learned about biodiversity in a traditional classroom setting (without XR) does not seem appropriate for the question regarding the moderating effect of affective and cognitive processes that were experienced while being in a virtual environment. In another yet-to-be-published paper [8], we will report the results of a control group study (XR vs. traditional classroom setting) with a focus on the general learning effects. To analyze the moderating effects of, for example, presence, other control groups (e.g., comparing different mobile devices) would be more suitable.

Additionally, regarding the qualitative portion of our study, it is debatable whether the questions in the interview guide were suggestive or at least formulated with a positive expectation. This may have contributed to the students predominantly making positive statements about the XR application. In turn, this could have deterred classmates from giving negative responses due to social pressure, even when the moderators explicitly asked for them. It should also be noted that most contributions came from male students, while female students were shy and reserved. This could negatively impact the generalizability of the results. Moreover, the results may be biased by the fact that students with a large knowledge base participated more actively in the focus group than those who are not interested in the topic or have little knowledge about it. Also, the size of the focus groups could have influenced the students' response behavior. The willingness to participate in the focus group discussion might have been lower in larger groups compared to smaller ones, which could be attributed to diffusion of responsibility [84,85].

Furthermore, methodological concerns could be raised. The knowledge test for this part of the project consists of a singular item measuring self-reported knowledge on the domain of the Amazon rainforest. This means that students who overestimated their knowledge in the pretest may have gained knowledge during the intervention but may have rated their knowledge lower in the posttest, after getting a better perspective on what they do and do not know. Therefore, actual knowledge gain may not be reflected in the difference between pre- and posttest. Our interpretations regarding knowledge gain and the adjacent effects should be treated cautiously. It should, however, be noted that students in the focus groups were still able to reproduce information gathered in the XR-based lesson, implying that learning about the topic did, in fact, take place.

Relating to the above-mentioned lack of time for critical reflection, the short duration of our study is a further notable limitation. The development of more sustainable attitudes in young people is significant for the future of our world. This study only examined a period from immediately after using the application to a maximum of two weeks afterward. To achieve long-term attitude changes, a more prolonged engagement of students with environmental issues is required, accompanied by scientifically guided long-term studies.

6.4. Future Perspectives

This study assumed that the students had sufficient skills in dealing with new technologies. The study paid little attention to technical issues. Some students who were still inexperienced with such technologies may have been disadvantaged. Furthermore, the lesson did not include systematic follow-up and critical reflection on the virtual experience. The discussion around the need for emersion after immersive experiences [86–88] posits the ontological question of to what degree virtual worlds are being perceived as genuine realities [89]. Nevertheless, the focus groups indicated that students discussed the XR application in their free time. However, from a research perspective, it would be interesting to examine students' metacognitive processes when learning with such technologies.

Students in the focus groups showed emotional involvement in the content presented in the XR experience. Long-term changes in attitude and behavior might be achieved by teachers who try to capture the students' emotions in discussions after using the XR application. Future research could address the specific learning emotions [90] elicited by the application and their possible benefit for learning outcomes.

7. Conclusions

Overall, this paper shows that presence and flow are in fact relevant moderators that can affect learning outcomes in XR applications. An interesting conclusion we draw from the study is that these experiential learning processes are pivots for the lever that is XR technology: These processes can help facilitate the VR and/orAR experience. Technical advancements could further support the learning outcomes. Hence, care should be taken to improve the perception of presence and flow by users when implementing AR and VR technology, especially for learners with little prior knowledge.

In general, the greenpeace XR application On Biodiversity's Tracks can be classified as an effective application that achieves a reflective and affective engagement with environmental issues such as the threat to biodiversity. Its use in class was perceived very positively by the students. The application can therefore assist teachers in designing lessons on sustainability topics for middle school students. Thus, the application seems to be one method to communicate SDGs appropriately.

Supplementary Materials: A screenshot of the miro board slides used within the focus groups can be found here: https://rb.gy/4zcnr (accessed on 30 November 2023). All questionnaires as well as the manual for the teachers and an interview guide for the focus groups can be found here: https://shorturl.at/bcgmI (accessed on 30 November 2023). The material containing extended statistics can be found here: https://shorturl.at/aoK26 (accessed on 30 November 2023).

Author Contributions: M.M. led the study. In collaboration with K.H.T., she was responsible for the conceptualization of the study design, the selection of methods, and the creation of the research materials. K.H.T. took charge of analyzing the quantitative data. In collaboration with a research assistant, K.H.T. and M.M. supported the analysis of qualitative data and the creation of research materials. The interpretation of the data and their documentation in this article was a collaborative effort between K.H.T. and M.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by greenpeace e.V. Germany (January 2023–June 2023). Furthermore, we acknowledge support by the Open Access Publication Fund of the University of Duisburg-Essen.

Institutional Review Board Statement: Ethical review and approval were waived for this study because all subjects participated in the study voluntarily and without further constraints.

Informed Consent Statement: Before the students participated in the study, teachers as well as parents and students received information about the experiment, giving parents the option to opt their children out of the study.

Data Availability Statement: Data can be downloaded at: https://shorturl.at/vzGQZ (accessed on 30 November 2023).

Conflicts of Interest: The authors declare no conflict of interest.

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Application of Business Simulation Games in Flipped Classrooms to Facilitate Student Engagement and Higher-Order Thinking Skills for Sustainable Learning Practices

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Abstract: It is very important to adopt innovative digital technologies in educational systems to overcome the challenges in modern learning environments, especially in the post-COVID-19 era. The fourth Sustainable Development Goal (SDG) of the 2030 Agenda is supported by new educational trends that consider game-based learning as a pedagogical method in the classroom. Teaching sustainability management in higher education institutions with innovative digital tools plays a fundamental role in the transition toward sustainable societies. Suitable game design elements play a significant role in facilitating sustainable learning. This study explored the effectiveness of incorporating business simulation games with project-based learning (PBL) in a flipped classroom setting. This approach was adopted within the context of a university cross-border e-commerce course to prepare students for acquiring 21st-century skills such as higher-order thinking skills in a rapidly changing educational landscape. A quasi-experimental method was employed, involving a total of 60 university students from China's Zhejiang Province. Participants completed an online questionnaire designed to assess their learning engagement across three dimensions (cognitive, emotional, and behavioral) as well as their higher-order thinking skills (problem-solving, critical thinking, and creativity). The results show that the business simulation games combined with flipped classroom learning had a significantly positive impact on students' learning outcomes, enhancing their problem-solving, critical thinking, and creative capabilities. Importantly, this approach also improved student engagement and promoted sustainable practices by applying real-life scenarios in an interactive environment. We conclude that business simulation games integrated with project-based learning (PBL) in flipped classroom settings represent a valuable educational approach. This approach not only enhances learning engagement but also fosters the development of higher-order thinking skills, encouraging students to adopt sustainable learning practices.

Keywords: business simulation games; higher-order thinking skills; sustainable learning practices

Citation: Hsu, C.-Y.; Wu, T.-T. Application of Business Simulation Games in Flipped Classrooms to Facilitate Student Engagement and Higher-Order Thinking Skills for Sustainable Learning Practices. *Sustainability* **2023**, *15*, 16867. https://doi.org/10.3390/su152416867

Academic Editor: Wayne Sailor

Received: 29 October 2023
Revised: 9 December 2023
Accepted: 13 December 2023
Published: 15 December 2023

1. Introduction

The COVID-19 pandemic has adversely impacted progress towards achieving the Sustainable Development Goals (SDGs) related to education. These goals strive to provide lifelong opportunities for both youth and adults by equipping them with essential skills and knowledge [1]. In this context, educational institutions bear a crucial responsibility to impart students with the fundamentals required for sustainable learning, thus enabling them to effectively surmount complex and challenging situations. To cope with sudden market changes and thrive in a complicated environment. Business simulation games are instrumental in achieving this goal, because they provide a true representation of market processes in a safe and dynamic virtual environment and can assist in developing professional and decision-making skills while considering real-world surroundings [2–6]. Moreover, the gaming platforms help students put theories with flipped learning into

practice for enhancing engagement and higher-order thinking skills in a virtual environment. Consequently, these institutions must ensure that as learners successfully navigate these challenges, they make a vital contributions towards the fulfillment of the Sustainable Development Goals (SDGs) in their respective nations [7,8]. In the wake of the COVID-19 pandemic, college graduates are facing formidable difficulties in their job searches. However, the disruptions caused by the COVID-19 pandemic have fueled the growth of online entrepreneurship [9], opening up a myriad of new opportunities [10]. Simultaneously, the burgeoning digital economy has led to the emergence of novel entrepreneurial avenues such as cross-border e-commerce, influencer marketing, and game streaming [11], offering a wealth of new entrepreneurial prospects for university graduates. The establishment and openness accessibility of digital platforms have considerably reduced the barriers to entry and the costs traditionally associated with entrepreneurship. This undoubtedly creates an environment conducive to university students with limited financial resources who aspire to venture into the entrepreneurial landscape [9].

Cross-border electronic commerce (CBEC) refers to international trade conducted through the internet and encompasses electronic commerce transactions, payment settlements, and international logistics transportation across different countries [12]. CBEC has become a significant contributor to regions within the global economy driven by e-commerce, rapidly developing to become one of the most resilient platforms [13]. CBEC and entrepreneurship have increasingly gained academic recognition in recent years, leading several higher education institutions in China to embrace related educational programs. However, the rapid development of CBEC has led to most B2C platforms gradually canceling individual registration, and instead only allow the registration of accounts for licensed companies or brands. This shift places a financial obstacle in the way of enterprising students who lack the funds for company registration. As a result, teachers and students alike are unable to engage in sustainable learning practices in B2C CBEC platform activities, with courses comprising lectures and discussions that may provide theoretical insights but fail to provide real-world experiences, leaving students with minimal training on project implementation and practical learning [14,15]. This further decreases students' classroom engagement and limits their opportunities for cultivating higher-order thinking skills and abilities. Several studies have highlighted that the traditional techniques and methods for teaching entrepreneurship and business courses do not adequately prepare learners to adapt to sudden market changes or operate in complex, real-world scenarios [16–18]. To address this issue, computer-assisted learning, including business simulation games, can realistically depict market processes within a secure, sustainable, digital, and dynamic virtual environment. These games play a pivotal role in cultivating professional and informed decision-making while increasing learning engagement and higher-order thinking skills by prompting individuals to make choices similar to those made in real-world scenarios [19,20]. Several studies have advocated for the use of business simulation games to boost creativity, individual motivation, critical thinking, team management, collaborative skills, time management, experiential learning, and dedication to entrepreneurship [21–25].

Based on these advantages, this study aimed to implement a business simulation game, "CEMO Simulation", in combination with project-based learning (PBL) in a flipped classroom. Despite numerous studies exploring the use of business simulation games, there has been limited research on the application of CBEC-based games in flipped classrooms and intermediate courses to enhance learning outcomes through the development of higher-order thinking skills and increased learning engagement. Moreover, the convergence of flipped learning and gamification represents a new teaching methodology and an innovative approach tailored to the evolving demands of education in the new millennium [26,27].

2. Literature Review

2.1. Educational Considerations Regarding the Flipped Classroom

The flipped classroom describes a mixed methodology that combines face-to-face and virtual teaching methods and is currently being employed at all educational levels. Its increasing use has been attributed to its overall effectiveness and the specific practical components that constitute its training approach [27–29]. However, to maximize the benefits of this innovative pedagogical approach, it is essential to ensure active student engagement to facilitate the effective acquisition of knowledge [30]. There is a close relationship between the flipped classroom and the instructional objectives of Bloom's Taxonomy. In traditional teaching settings, teachers primarily engage in knowledge dissemination. In the flipped classroom, students independently study basic concepts, completing lower-level learning (i.e., memorization and comprehension) by themselves, while higher-level learning skills (i.e., application, analysis, evaluation, and creation) are achieved through interaction with educators in the classroom [31]. Research has found that the flipped classroom not only encourages students to engage in active learning before class, but also improves their class learning [32]. Moreover, educators are tasked with providing engaging activities within the classroom that promote team work through group projects, coordinated discussions, debates, lectures, pitch reports, presentations, gamification, and other forms of active participation [33]; higher-order thinking [34]; and learning achievements [35]. The literature has reported the successful implementation of flipped classrooms across various fields, including engineering [36], mathematics [37], education [38], business [39], and entrepreneurship [40], to name a few. Conventional educational systems have failed to nurture the essential skills students need to apply theoretical knowledge in real-world businesses [41,42]. Furthermore, flipped learning has the potential to address the limitations of traditional, teacher-centered teaching strategies by adopting a student-centered model that motivates students to apply theoretical knowledge and essential skills in practical contexts using a wide range of activities [43–45]. Based on these findings, the present study adopted the flipped classroom as the teaching methodology to increase student engagement and sustainable learning practice.

2.2. Particulars of Game-Based Learning in Education

According to Gabrielsson, Tell, and Politis [46], business schools and policymakers have faced substantial criticism for disproportionately burdening students with theoretical and academic knowledge instead of equipping them with practical, real-world skills, a concern that has been shared by both researchers [47] and educators [48,49]. Consequently, there are compelling reasons to adopt new technologies in educational systems. According to Abourezk [50], students tend to acquire a deeper understanding when they engage with experiential and practical knowledge rather than passively listening to classroom lectures. Business simulation games, which provide an interactive, exciting, and enjoyable learning environment [51,52], have been supported by researchers whose work has revealed that business simulation games can increase motivation [53] and enhance creativity and learning [54,55]. Furthermore, business simulation games have gained widespread use in business education to enhance engagement, improve higher-order thinking, and achieve specific learning objectives. Several studies have demonstrated the effectiveness of game-based learning in reinforcing theoretical concepts and creating an immersive learning environment that aids students in developing higher-order thinking skills through challenging problem-solving tasks [2,56,57]. Researchers have highlighted the use of business simulation games in business and entrepreneurial studies, marking a paradigm shift from conventional teaching methods toward innovative teaching practices.

2.3. Educational Considerations Regarding Project-Based Learning

Education should adjust to a dynamic world, and project-based learning (PBL) is gaining popularity as it effectively addresses this demand [58,59]. PBL is an educational model centered on project-based activities [60]. In the PBL process, students identify

problems, develop the skills to gather and integrate information, enhance communication through group discussions, and work collaboratively to propose solutions [61,62]. In higher education, PBL equips students with a varied spectrum of knowledge and essential innovative skills, enabling them to effectively navigate future challenges and achieve success [63]. PBL has the potential to positively influence students' attitudes toward learning, leading to increased positive effects on both student learning effectiveness and engagement [63–66]. PBL is an inquiry-based, holistic instructional approach grounded in authentic contexts. It embodies a unique form of collaborative learning that prioritizes student-centered engagement with concrete, real-world artifacts [67,68]. Project-based learning (PBL) closely resembles real-world business scenarios and has been extensively adopted in higher education, particularly in the field of business education for authentic projects with actual corporations. The research presented in [65] implemented PBL in a business informatics university course. In this scenario, students acquire knowledge through practical application during the project elaboration, aligning with the principles of PBL. Throughout the process, students participate in hands-on activities, including exploring the basics of data processing, conducting data analysis, modeling business processes, and developing a simple system. Additionally, this pedagogical approach proves to be a highly effective method that seamlessly integrates into dynamic and demanding learning environments such as international business education [64]. In higher education, PBL enables students to gain a broad spectrum of knowledge and essential innovative skills crucial for addressing future challenges and attaining success [63]. Several studies have highlighted the positive influence of PBL on students' attitudes toward learning, resulting in enhanced effectiveness and engagement [63–66]. Using PBL to promote teacher–student interaction and foster students' active problem-solving skills in flipped classrooms necessitates the cultivation of higher-order thinking skills.

Numerous researchers have explored how the PBL approach can lead to higher-order thinking skills. These studies investigated PBL's impact on students' higher-order thinking skills via follow up questionnaires, and its effectiveness was confirmed by the empirical data. For instance, Sulisworo [36] attempted to enhance higher-order thinking skills through a PBL approach to STEM education by arranging a study in which the experimental group followed a PBL approach while the control group used traditional scientific learning methods. The results indicated a positive impact of the PBL approach on the students' higher-order thinking skills.

2.4. Learning Outcomes of Student Engagement

"Student engagement" refers to the effort that a student invests in learning activities and is influenced by a variety of factors and classroom dynamics [69]. Regardless of the mode of learning, student engagement has been a focus of several studies due to its strong correlation with learning outcomes [70]. Engagement constitutes a critical component in any educational endeavor, encompassing three key facets: behavioral, cognitive, and emotional engagement. Although student engagement is crucial, there remains a gap in the existing literature concerning engagement within the context of PBL in flipped classrooms, particularly when integrated with business simulation games for students majoring in CBEC-related courses. Therefore, this study sought to bridge this gap by providing insights on student engagement in business school settings that combine PBL and flipped classrooms where business simulation games for CBEC practice have been incorporated. Our findings can aid educators in developing a more engaging curriculum and learning activities that promote active learning and advanced skills.

2.5. Learning Outcomes of Higher-Order Thinking Skills (HOTS)

Recently, universities have been promoting higher-order thinking skills (HOTS) by incorporating technology into various educational contexts [70]. Attending a university offers students additional advantages, including the opportunity to nurture creative abilities that will not only serve them well in the workplace, but also in society. Problem-solving,

a key component of HOTS, requires the capacity to identify issues, collect and analyze relevant facts to generate solutions, and then, take decisive action. Creativity in this context means the ability to examine information objectively, think rationally and logically, and reach reasonable conclusions [70–72]. Hwang et al. [73] defined creativity as the ability to come up with new ideas, innovative concepts, and alternative approaches by explaining, modifying, exploring, and evaluating existing knowledge and resources. Kim et al. [74] examined the effectiveness of measuring educational success using HOTS and explored how it could be implemented in this context. Furthermore, in conjunction with continuous and rapid technological advancement, it is necessary that university students acquire new competencies in order to thrive in society. These competencies, often referred to as 21st-century skills, encompass high-level cognitive abilities. Therefore, HOTS incorporate 21st-century skills, encompassing the abilities students will need to succeed in the future [75].

Higher-order thinking and metacognitive skills are cultivated through engagement in classroom activities that motivate students to actively participate. Some studies have found that learning ability and engagement are closely associated with a student's HOTS [76]; therefore, educators need to explore and develop teaching methods that will nurture these skills [77]. The significance of HOTS is also evident in global skill studies that emphasize problem-solving skills and creativity in diverse and unanticipated environments [78], suggesting that HOTS is a vital indicator of the effectiveness of classroom instruction and employability [3].

In light of the existing literature, this study aimed to fill the present gap in research relating to business schools' focus on student engagement and higher-order thinking skills in the context of PBL in flipped classrooms integrating business simulation games. To evaluate the effectiveness of the proposed learning method. An experiment was con-ducted to answer the following research questions:

1. Can business simulation games (BSGs) enhance students' behavioral engagement in comparison with flipped classroom learning (FCL)?
2. Can business simulation games (BSGs) enhance students' emotional engagement in comparison with flipped classroom learning (FCL)?
3. Can business simulation games (BSGs) enhance students' cognitive engagement in comparison with flipped classroom learning (FCL)?
4. Can business simulation games (BSGs) promote students' problem-solving in comparison with flipped classroom learning (FCL)?
5. Can business simulation games (BSGs) promote students' critical thinking in comparison with flipped classroom learning (FCL)?
6. Can business simulation games (BSGs) promote students' creativity in comparison with flipped classroom learning (FCL)?

3. Methodology and Data Collection

3.1. Overview of Research Design

This study employed a mixed-method quasi-experimental design that integrated both quantitative and qualitative analyses to gain a comprehensive understanding of the phenomenon under investigation. A key feature of quasi-experimental designs lies in their ability to address a special aspect of the experimental group while simultaneously keeping all other elements constant between the experimental and control groups. The quasi-experimental design utilizes two types of variables: (1) independent variables, characterized by two different instructional strategies (flipped classroom learning and flipped classroom learning with simulation game learning), and (2) dependent variables, assessed through an evaluation of students' engagement and higher-order thinking skills. The research design for group comparison research is shown in Figure 1.

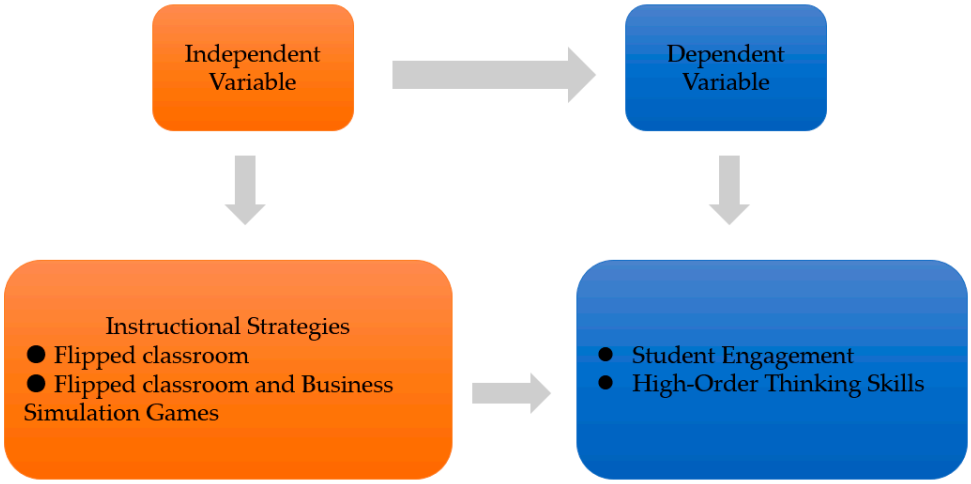

Figure 1. Research design.

3.2. Research Process

3.2.1. Experimental Procedure

The experiment consisted of nine class meetings, with each class lasting 80 min. An overview of the experimental procedure is presented in Figure 2. The initial period involved the distribution of pre-test questionnaires and a brief course lecture. After introducing the fundamental concepts, students in the experiment group were introduced to business simulation games for learning. All tasks required to complete the games were thoroughly explained, and the students were divided into groups of six members each to engage in various projects and tasks. From the first to the sixth meetings, students in the experimental group studied CBEC management using the PBL in flipped classrooms and business simulation games. Meanwhile, students in the control group also used PBL with flipped classroom learning, sans BSGs. Data collection occurred both at the outset and at the conclusion of the experiment. Before administering the questionnaires to the participants, researchers explained the research study's objectives. Following data collection and analysis, the researchers used the results to select participants for the interviews. During the seventh class, each team presented CBEC business plans, or "learning outcomes", which were evaluated by their instructor. In the eighth class, students completed post-test questionnaires. In the final stage (Class 9), ten students from the experimental cohort took part in interviews, with each interview lasting 40 to 70 min. The interview questions were designed to elicit additional insights into the experimental methods and to complement the quantitative data.

3.2.2. Experimental and Control Group HOTS Activities

Both the experimental and control groups were instructed by the same teacher, and the teaching content in each class was identical. Table 1 presents a detailed overview of the experimental and control group activities related to HOTS. The course emphasized the establishment of an effective virtual CBEC marketing and operating environment, encompassing market environments, the data analysis of eCommerce platforms, as well as specific operations and decision-making. The course content was organized into six sections. The first section involved a brief lecture introducing the concepts of business generation and market opportunity analysis. Section 2 provided details about procurement and supply chain management. Section 3 focused on product innovation within the context of a business model. Section 4 involved designing a marketing strategy within a business model framework. Section 5 largely consisted of financial analysis, while a comprehensive business strategy was developed in Section 6.

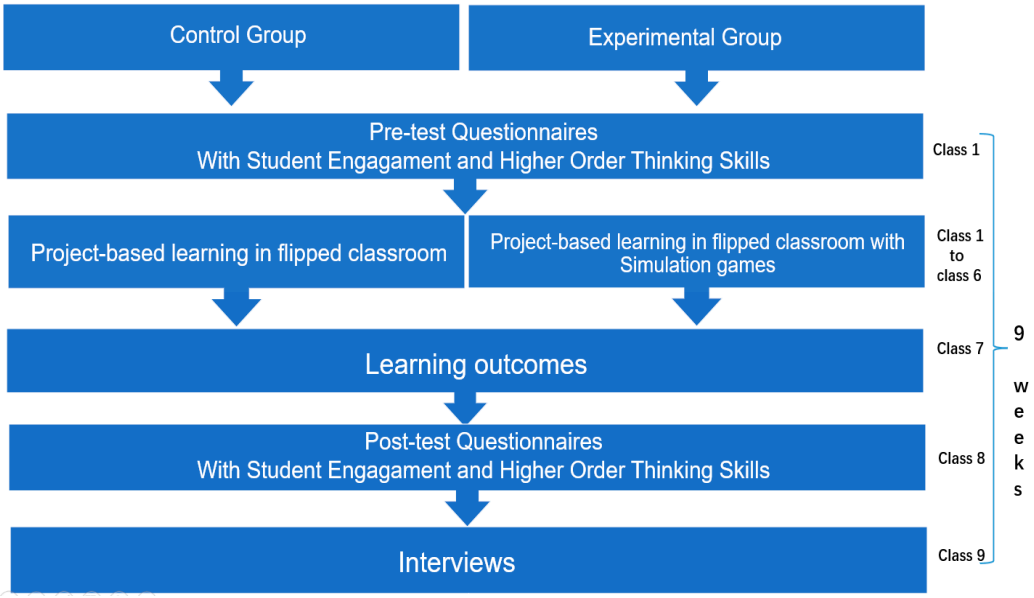

Figure 2. The experimental procedures of this study.

Table 1. The experimental and control group HOTS activities.

No (Section)	Instructional Content with PBL	Group		HOTS Activities		
		Control Group	Experimental Group (CEMO Simulation)	Problem-Solving	Critical Thinking	Creativity
1	Introduction • Business introduction • Market opportunity analysis • Create a new company	Video assignment: how to create a new business/company • Confirm company mission • Conduct a market analysis • Determine an appropriate new company		• Analyze market information and market demand • Create new company	• Determine how to operate company	• Design a company name and logo
2	Business process • Procurement • Supply chain management • B2C wholesale	Video and slideshow: procurement management • Customize initial demand • Perform material requirement planning • Determine purchase price • Implement supply chain management		• Determine and analyze the market value • Develop a procurement plan	• Assess supply chain competition and company sales	• Integrate idea generation with company plan and forecast future market behavior
3	Business model • Create a new shop on the e-commerce platform • Create posts to sell products via e-commerce	Video assignments: how to register a new company and upload products • Register new account • Obtain required materials for product listing and product details to upload to the platform • Determine the sale price for each item		• Determine and analyze the production plan and create product listings	• Determine the best way to upload product	• Design innovative products
4	Marketing strategy • Marketing programs • Social media marketing • Marketing fees	Video and slideshow: how to analyze marketing programs • Assess the competitive landscape within the market • Conduct a marketing program for the company • Develop social media marketing		• Analyze marketing program • Develop social media marketing	• Analyze data from marketing program • Conduct innovative marketing strategies to increase sales growth	• Design creative social media and marketing activities

Table 1. *Cont.*

No (Section)	Instructional Content with PBL	Group		HOTS Activities		
		Control Group	Experimental Group (CEMO Simulation)	Problem-Solving	Critical Thinking	Creativity
5	Business plan • Assess initial costs • Determine loan parameters • Delinquency payouts • Financial analysis	Slideshow: how to create a financial report • Request financial aid • Analyze and create reports • Analyze profit reports • Analyze inventory data reports		• Conduct financial analysis • Conduct order report, profit report, and inventory report	• Evaluate financial status • Determine optimization scheme to improve cost structure • Reduce inventory costs and enhance inventory turnover	• Design innovative solutions for cost reduction • Explore optimization of financial operations
6	Business Strategy • Create a company model • Create a business plan display	Video and slideshow: business model • Create a company model • Present business plan		• Analyze business strategies and make necessary adjustments • Develop business model	• Formulate a financial strategy	• Design a business plan

3.3. Business Simulation Games (BSGs)

All the PBL tasks required to complete the games were discussed with the students through groups. This research utilized a simulation game licensed under the name "Cross-border e-Commerce Marketing and Operating Simulation" (CEMO Simulation) and was specially designed to provide a virtual CBEC operating environment. The online BSG CEMO Simulation encompasses market environments, data analysis of eCommerce platforms, and other specific operations. It offers further flexibility through the integration of various business aspects during simulations to regulate the difficulty level of the player experience. We applied the PBL in a flipped classroom using CEMO Simulation to enhance higher-order thinking skills in sustainable learning practices. Each CEMO Simulation section within the games included a brief description and learning activity designed according to the PBL approach, as detailed below:

1. Introduction: In this section, students begin the game by starting a new company. Students assume various roles within the company and take responsibility for their positions in order to manage the firm. This section covers a business introduction, CBEC market opportunity survey, and market environment analysis.
2. Procurement: This section involves activities related to material requirement planning and supply chain management decisions. The game gradually introduces new decision-making content relevant to the company's procurement life cycle.
3. Production: Within this section, students select a B2C CBEC platform and create posts to buy and sell. Students need to present their decisions in a logical sequence.
4. Marketing: This section focuses on marketing programs and marketing strategy. Students are tasked with reinforcing their strategic decisions by linking them with cash flow and profitability considerations.
5. Finance: The final section allows the instructor to customize the initial costs, loan parameters, and funds. Students need to make repeated decisions regarding essential loans, costs, and profits, as well as develop strategies to maximize profitability.

Students were given the opportunity to create an e-commerce shop, identify goals, evaluate market surveys, develop strategies, upload innovative products to target specific markets, and develop new and innovative products (see Figure 3). The games are organized into sections based on PBL activities to encourage students to make strategic decisions

according to potential consequences. In flipped classrooms, it is essential that students grasp the theoretical foundation of the material prior to class; once in the class, the instructor provides additional details about the overarching framework and guides the students as they complete the game tasks. Students' primary objectives with the simulation games are to identify business challenges and find ways to address them. When the games end, CEMO Simulation provides the instructor with a report regarding the students' development, along with additional information. The instructor can then guide each group of students in summarizing their decision-making processes, identifying problems encountered in the games, and analyzing the reasons for a company's success or failure, including instances of bankruptcy. Each group shares their thoughts and engages in discussions and reflection sessions, helping students connect their game experiences to the real world, promoting the learning process. At this stage, the most innovative group is selected and recognized for having gained practical experience. Finally, the instructor provides feedback on the simulation games and each group's reflections using evaluations.

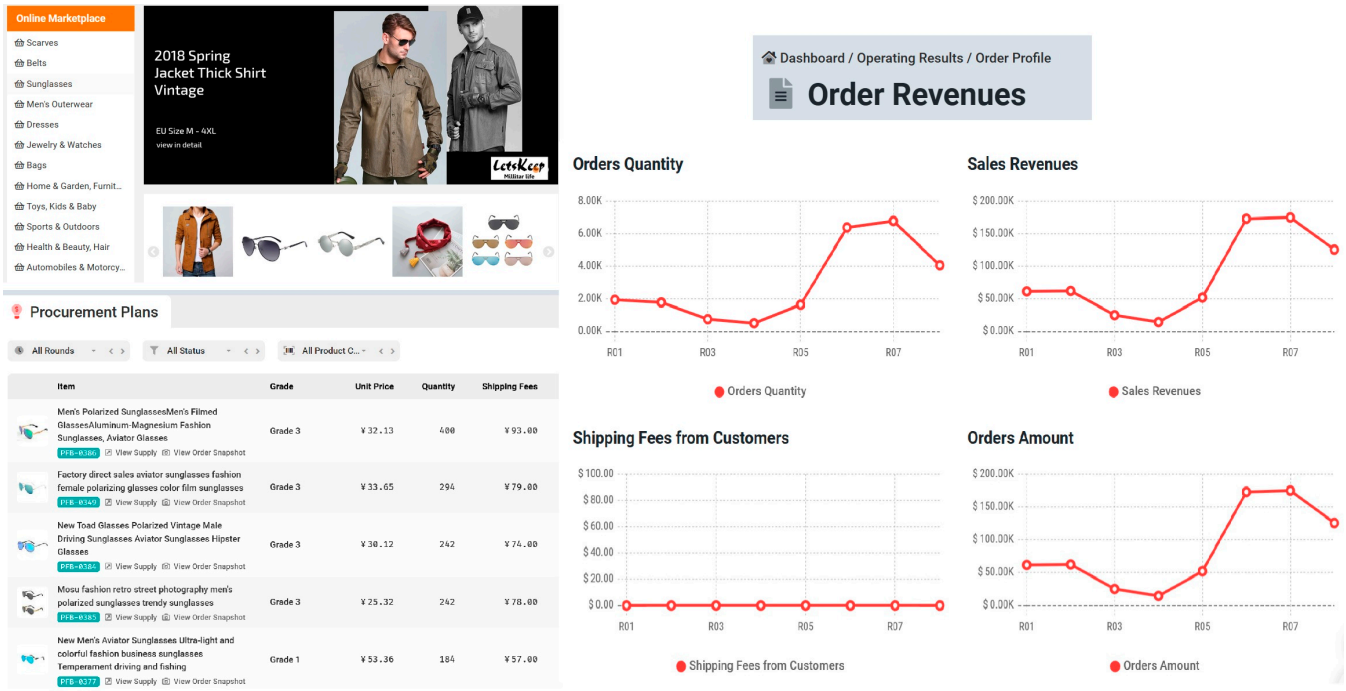

Figure 3. The CEMO Simulation interface.

3.4. Participants

This study included 60 participants, all of whom were sophomore students majoring in international e-commerce at a university in Zhejiang Province, China. These students were divided into two groups: the experimental group (n = 30) and the control group (n = 30).

3.5. Research Instruments

This research implemented a pre-test, a post-test questionnaire, and interviews conducted throughout the experiment. The questionnaire on students' engagement was developed based on Reeve and Tseng [78] and consisted of 17 items organized into three domains: behavioral, cognitive, and emotional engagement. The reliability test results are presented in Table 2, where Cronbach's alpha values are 0.894, 0.865, and 0.918 for the behavioral, emotional, and cognitive domains, respectively. As all values are higher than the suggested threshold value of 0.7, the results can be considered reliable. The HOTS questionnaire was adopted from a study by Hwang et al. [70], which consisted of 11 items organized into three domains: problem-solving, critical thinking, and creativity.

Problem-solving involves identifying problems and analyzing relevant materials and information. Critical thinking pertains to the cognitive ability to make logical judgments. Finally, creativity refers to the capacity to create and improve on original concepts. Table 2 shows that all constructs related to higher-order thinking skills were considered reliable, with Cronbach's alpha values of 0.925, 0.940, and 0.768, respectively. Again, good reliability is determined by values exceeding the suggested threshold value of 0.7.

Table 2. The instrument reliability test results.

Variables	Construct	Reliability
Student engagement	Behavioral engagement	0.894
	Emotional engagement	0.865
	Cognitive engagement	0.918
Higher-order thinking skills	Problem-solving	0.925
	Creativity	0.940
	Creativity	0.768

3.6. Data Collection

Data were collected via pre- and post-test questionnaires that measured classroom engagement and higher-order thinking among participants in both the experimental and control groups. These questionnaires were then collected and the quantitative data were entered into SPSS 25.0 for data analysis. For statistical analysis, descriptive statistics and a one-way analysis of covariance (ANCOVA) were used. The results indicated homogeneity in behavioral engagement (F = 0.081, p = 0.777), emotional engagement (F = 0.287, p = 0.594), and cognitive engagement (F = 0.853, p = 0.360), as well as problem-solving (F = 0.377, p = 0.542), critical thinking (F = 3.18, p = 0.080), and creativity (F = 0.881, p = 0.352). These results confirmed that the regression coefficients of the groups did not reach significant levels, supporting the assumption of homogeneity in covariance analysis and allowing for the use of one-way ANCOVA to test for significant differences between the groups' pre- and post-test scores. Additionally, interviews were conducted with students to gain insights into their learning experiences. The interview data were recorded and transcribed, and comprehensive details of these interviews are provided in Appendix A.

4. Analysis and Results

4.1. Analysis of Student Engagement

In line with the proposed questions and their underlying framework, the complete and usable pre- and post-test data obtained from the 60 participants in the quasi-experiment were used for the dependent variables. Descriptive statistics were used to analyze these variables (as shown in Table 3), revealing improvements in student engagement for both the experimental and control groups following their participation in the training courses. A subsequent analysis of covariance (ANCOVA) test was used to assess differences between the pre- and post-test scores for all dependent variables. The results indicated significant differences in the post-test scores for behavioral engagement and cognitive engagement between the two groups, as shown in Table 4.

Table 3. The descriptive results for student engagement.

Variable	Group	Pre-Test		Post-Test	
		M	SD	M	SD
Behavioral engagement	Experimental	3.48	2.111	4.69	1.478
	Control	3.07	0.922	4.43	2.520
Emotional engagement	Experimental	3.21	1.507	4.59	1.671
	Control	2.95	1.006	4.39	2.434
Cognitive engagement	Experimental	3.17	2.102	4.61	2.149
	Control	2.95	1.422	4.26	3.960

Table 4. The ANCOVA results for student engagement.

Variable	SS	df	Mean Square	F	*p*	Partial η^2
Behavioral engagement	0.911	1	0.911	5.274	0.025 *	0.085
Emotional engagement	0.446	1	0.446	2.518	0.118	0.042
Cognitive engagement	1.382	1	1.382	6.581	0.013 *	0.104

* $p < 0.05$.

4.1.1. Analysis of Behavioral Engagement

In terms of behavioral engagement, the ANCOVA results in Table 4 show significant differences between the groups (F = 5.274, $p < 0.05$, 0.025). Based on the post-test mean scores (see Table 3), students in the experimental group (M = 4.69, SD = 1.478) showed higher levels of behavioral engagement compared to students in the control group (M = 4.43, SD = 2.520). These results support the assertion that students in the experimental group demonstrated significantly higher behavioral engagement after participating in the BSG learning activities, thereby confirming research question 1.

4.1.2. Analysis of Emotional Engagement

Regarding emotional engagement, the ANCOVA results in Table 4 show no significant differences between the groups (F = 2.518, $p = 0.118$), resulting in the rejection of research question 2. However, it can still be observed from Table 3 that the post-test mean score for students in the experimental group (M = 4.59, SD = 1.671) was higher than that of the students in the control group (M = 4. 39, SD = 2.434).

4.2. Analysis of Higher-Order Thinking Skills

Table 5 provides descriptive statistics showing that both the experimental and control groups demonstrated improvements in higher-order thinking skills following the course training. Subsequently, an analysis of covariance (ANCOVA) was used to analyze the differences between the students' pre- and post-test scores. The results indicate that there were significant differences in problem-solving, critical thinking, and creativity between the two study groups, as shown in Table 6.

Table 5. The descriptive results for HOTS.

Variable	Group	Pre-Test		Post-Test	
		M	SD	M	SD
Problem-solving	Experimental	3.33	1.539	4.39	2.176
	Control	2.96	1.085	4.33	1.968
Critical thinking	Experimental	3.10	1.567	4.42	2.354
	Control	2.84	1.159	4.22	2.501
Creativity	Experimental	3.14	1.040	4.44	1.688
	Control	2.87	1.192	4.21	1.752

Table 6. The ANCOVA results for HOTS.

Variable	SS	df	Mean Square	F	*p*	Partial η^2
Problem-solving	31.533	1	31.533	18.563	0.000 ***	0.249
Critical thinking	11.554	1	11.554	6.620	0.013 *	0.106
Creativity	8.422	1	8.422	6.790	0.012 *	0.108

* $p < 0.05$, *** $p < 0.001$.

4.2.1. Analysis of Problem-Solving

The ANCOVA results in Table 6 show significant differences in problem-solving scores between the two groups (F = 18.563, $p < 0.05$, 0.000). As can be seen in Table 5,

the experimental group had significantly higher average post problem-solving scores (M = 4.39, SD = 2.176) than the control group (M = 4.33, SD = 1.968). These results indicate that the use of BSG learning in a flipped classroom led to greater improvements in students' problem-solving skills compared to a flipped classroom, thereby confirming question 4.

4.2.2. Analysis of Critical Thinking

Regarding critical thinking, the ANCOVA results in Table 6 show significant differences between the two groups (F = 6.620, $p < 0.05$, 0.013). Based on the post-test mean scores (Table 5), students in the experimental group had higher scores (M = 4.42, SD = 2.354) than the control group students (M = 4.22, SD = 2.501). This indicates that the experimental group demonstrated significantly higher critical thinking abilities compared to the control group, thereby confirming question 5.

4.2.3. Analysis of Creativity

With respect to creativity, the ANCOVA results in Table 6 also show significant differences between groups (F = 6.790, $p < 0.05$, 0.012). As seen in Table 5, the experimental group had higher post-test mean scores (M = 4.44, SD = 1.688) compared to the control group (M = 4.21, SD = 1.752). These results indicate that the experimental group exhibited significantly higher creativity compared to the control group, which can be attributed to the implementation of the BSG intervention, thereby confirming question 6.

5. Discussion

This study assessed participants' behavioral engagement, emotional engagement, cognitive engagement, and higher-order thinking skills following the integration of business simulation games using a project-based learning approach in a flipped classroom. The results of this study support the use of BSGs to enhance behavioral and cognitive engagement while cultivating HOTS to promote sustainable learning and practices. In the PBL flipped classroom, students enrolled in CBEC courses following a course schedule arranged by their instructor while combining strategies including weekly previewing and reporting. This approach promotes active learning and leverages the principles of PBL to enhance teamwork, and encourage the application of knowledge for solving tangible problems [61,62,79]. Incorporating BSGs into this context creates a learner-centered environment that can significantly improve students' cognitive and behavioral engagement through systematic operations while contributing to the development of their higher-order thinking skills [36]. The results show a beneficial impact on student engagement and higher-order thinking skills compared to previous studies, which is in line with the previous findings [2,30,55]. In addition, the results show that involving BSGs enables the learning of skills by simulating real-time experiences in the virtual environment, which is consistent with earlier findings [30,80] and also in line with a study conducted by Deterding et al. [80].

The apparent lack of effect on emotional engagement may be attributable to the following considerations: According to interviews with students, the course utilized in this experiment is a mandatory sophomore course and required professional English skills to upload products to the B2C platform and reply to customers with good service. In this course, students need to possess a comprehensive interdisciplinary knowledge base, coupled with a background in financial management to safeguard the company against insolvency, a process that entails a heavy course load and high stress [2]. Within this context, students in both the experimental and control groups must focus on learning related to specific course tasks, directly impacting their level of emotional engagement during the learning process.

BSGs provide a dynamic and realistic business environment that not only fosters active learning but also establishes a robust collaborative relationship between BSG- and PBL-based flipped classroom activities. This combination of the teaching methodology of BSGs with project-based learning in a flipped classroom setting has been shown to motivate students to become actively engaged in the learning process. Through challenging the

students with tasks that engage them in the learning process, students will constantly engage in solving complex problems and decision-making. These activities foster competition among students through teamwork and cultivate higher-order thinking skills. It is important to emphasize the importance of incorporating new technology of games into the classroom because it enhances engagement, and BSGs should also be included in business and management courses to enable students to explore business operation based on realistic experiences, developing their decision-making skills. To ensure high-quality education, BSGs that support education must be implemented. Thus, with the aforementioned interventions, the promotion of the fourth Sustainable Development Goal (SDG 4) of the 2030 Agenda can be achieved. This objective underscores the importance of providing access to high-quality education for all students and fostering opportunities for lifelong sustainable learning [81]. Moreover, the competitive element in team-based simulations has also been shown to enhance creativity [4]. Teachers also have a key role as they guide students to summarize and review their decisions, identify problems encountered during game-based learning [4], and analyze the reasons for a company's success or failure. Thus, teachers should emphasize enhancing students' behavioral engagement, achievable through class discussions, collaborative group work, and various other activities. Consequently, this approach can elevate the overall level of learning engagement, facilitating the improved development of students' higher-order thinking skills, which is in line with previous findings [2,4].

As each group shares their ideas and leads discussions, these skills are further enhanced. In the final stage, the most creative group is identified and recognized for their contribution to sustainable learning through the practical experience they have obtained, thus encouraging other students to cultivate sustainable learning practices as well.

6. Conclusions

The use of BSGs is quickly gaining momentum throughout universities in mainland China, with substantial investments being made to purchase related software. However, in the field of CBEC, many gamified learning approaches merely involve hands-on operations and repetitive actions without actively developing students' higher-order thinking skills. Therefore, the teaching methods employed by instructors play a crucial role in the success of business simulations game learning. In this study, we compared PBL in a flipped classroom setting and PBL to a flipped classroom with the integration of BSGs. The main contributions, limitations, and directions for future research are summarized below.

This study offers several innovative contributions: (1) the combination of BSGs with PBL in flipped classroom learning activities to effectively enhance student engagement and higher-order thinking for sustainable learning practices; (2) the adoption of a quasi-experimental design to allow for an analysis of the differences in student engagement and higher-order thinking between PBL in a flipped classroom and a flipped classroom that incorporate BSGs; and (3) qualitative case interviews to provide a deeper understanding of the factors affecting student engagement and higher-order thinking. (4) For interdisciplinary professional courses, teachers should consider students' curriculum pressure.

Despite these contributions, the limitation of this study was also identified, leading to potential avenues for future research. The study's sample size was relatively small. In the future, more classes and participants should be involved to increase the sample size. Similar courses in the future should explore the relationship of curriculum loading with student engagement and higher-order thinking. Finally, more research on BSG courses could help establish best practices and provide educators with sustainable approaches for implementing BSGs with project-based learning (PBL) in a flipped classroom setting. It is concluded that educational interventions such as BSGs are crucial innovative tools, enabling educators to design a more engaging curriculum and learning activities that promote both student engagement and higher-order thinking skills. Thanks to technological advancements fostering students' holistic development and delivering high-quality education, in accordance with the fourth Sustainable Development Goal (SDG) of the 2030

Agenda [81], there is emphasis on achieving significantly more engaging future education using novel tools and the importance of quality education and skills development [5,81,82].

Author Contributions: Methodology, conceptualization, investigation, formal analysis, C.-Y.H.; validation, T.-T.W.; original draft preparation, T.-T.W. and C.-Y.H.; review and editing, C.-Y.H. and T.-T.W.; supervision, T.-T.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research is partially supported by the Ministry of Science and Technology, Taiwan, R.O.C., under Grant Nos. MOST 110-2511-H-224-003-MY3 and MOST 111-2628-H-224-001-MY3.

Institutional Review Board Statement: Not applicable.

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

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

Acknowledgments: The authors are grateful to the anonymous reviewers for their insightful comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of the data; in the writing of the article; or in the decision to publish the results.

Appendix A

Extracts from interviews with students: About behavioral engagement:

1. This kind of classroom operation task is more interesting, and I will be more focused.
2. In the past, classroom teaching only emphasized theory and simple explanations, which were relatively superficial. Nowadays, combined with specific practical operations, teaching can be better implemented.
3. The previous classes were quite dull, with only textbook content explanations, and it was easy to zone out. This type of class-room that combines theory with practical operations is more likely to stimulate students' interest.

About emotional engagement:

1. The teacher's open classroom has inspired our ability to think independently after the game was done, which is very interesting.
2. I required professional English skills to upload products and reply customer with good service.
3. The course workload is heavy and the pressure is relatively high.
4. It requires a background in financial management, avoiding company bankrupt is quite challenging.

About cognitive engagement:

1. When there is a mistake during the operation process, I check where the problem is and correct it. After completing it, I feel a sense of accomplishment in my heart.
2. I use the knowledge I have mastered to create questions and provide answers.
3. If I encounter a question that I don't know how to answer, I search for materials and analyze similar questions to solve it.
4. I reflect on whether my operation is correct.
5. I actively think about the content, significance, and application of learning, and recall relevant information that I have learned before when I am thinking.

About problem-solving:

1. Following the steps to solve problems, if I encounter questions that I cannot solve, I discuss them with team members to find solutions. This approach has enabled me to solve platform questions.

2. One of the important things I have learned is to reflect on and answer the knowledge points after completing the lessons, which has improved my problem-solving ability.
3. When I encounter questions that I don't know how to answer, I either refer to textbooks or search for relevant information online or discuss with my team.

About critical thinking:

1. This teaching method is different from the traditional one, it is designed to work together with the computer to better apply practical concepts.
2. Following the operation process brings new insights, checking to see if the correct steps are completed and refining your own steps. After completing it, there is a great sense of accomplishment.
3. For the questions in the section slides presented by each group of students, I can objectively analyze the rationality, logic, relevance, etc., of the question.
4. Through this course, I have gradually learned to use creativity to view both problems and myself.
5. After independently completing a problem and getting the correct answer, there is a great sense of satisfaction in my heart.
6. During the operation process, I reflect on whether the operation is correct and check to ensure correct completion. After completing it, I have a great sense of achievement and satisfaction.

About creativity:

1. I try to work on new problems and strive to complete them independently.
2. I attempt to challenge new tasks without any guidance and try to complete them independently.
3. I constantly try to work on new problems and independently solve them or complete the tasks.

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Constructing Sustainable Learning Ecology to Overcome Burnout of Teachers: Perspective of Organizational Identity and Locus of Control

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Abstract: This study examined how organizational identity, locus of control, and their interrelationships affect teacher burnout. Utilizing a quantitative survey, data were collected from 105 teachers. The Maslach Burnout Inventory measured three burnout dimensions: emotional exhaustion, depersonalization, and personal accomplishment. Locus of control was assessed via Rotter's scale. Organizational identity was measured through the Multiple Organizational Identification Scale, assessing personal self-esteem, emotional professional identity, evaluative identification, self-classification, and team factors. PLS-SEM analysis found that external locus of control had a significant positive association with emotional exhaustion. Emotional professional identity showed robust negative relationships with depersonalization and exhaustion. Differences emerged between novice and senior teachers—identity and self-esteem were more relevant for novices, while team factors were more impactful for experienced teachers. Variations also occurred across genders, with identity and self-esteem more salient for females and team dynamics more influential for males. The study highlights the complex interplay between individual, relational, and organizational factors in shaping teacher burnout. An external locus of control may exacerbate exhaustion, while emotional professional identity seems to provide resilience. Support initiatives should account for teachers' evolving developmental needs and gender variations in burnout experiences. Fostering internal control beliefs, strong professional identity, and tailored support based on career stage and gender can potentially buffer against burnout. This study contributes insights to guide targeted efforts to promote teacher well-being, effectiveness, and retention. Learning in the workplace instead of paying more time for education services can be considered as overcoming burnout, redesigning and implementing digital teaching for sustainable teaching and learning for both teachers and students in order to construct a better learning ecology.

Keywords: burnout; digital technology; locus of control; organizational identity; sustainable learning

Citation: Altinay, Z.; Bicentürk, B. Constructing Sustainable Learning Ecology to Overcome Burnout of Teachers: Perspective of Organizational Identity and Locus of Control. *Sustainability* **2023**, *15*, 16930. https://doi.org/10.3390/su152416930

Academic Editor: María del Mar Molero Jurado

Received: 26 October 2023
Revised: 9 December 2023
Accepted: 15 December 2023
Published: 18 December 2023

1. Introduction

Educational practices that support the incessant development and healthy learning environment in which knowledge is collaboratively created and shared locally are referred to as sustainable learning [1,2]. It incorporates continuous, responsive, purposeful, and proactive learning where learners efficiently build and reshape their skills and knowledge base as environments change [3]. Part of the responsibilities of sustainable learning ecologies is to support the contemporary educational processes [4], where teachers still play pivotal roles in shaping students' interest and success in education [5]. Teachers play a crucial role in developing students' scientific attitudes and interests, especially for disadvantaged students [5,6]. Their influence extends beyond the classroom, impacting the future of scientific research, innovation, and social progress. However, heavy workloads,

resource constraints, and other challenges can negatively impact teachers' well-being and effectiveness in the digital era [7,8]. Teacher burnout, a psychological phenomenon affecting educators globally, has major implications for the quality of instruction students receive and can undermine the overall educational experience [9]. It is thus critical to examine factors that may contribute to or protect against burnout among teachers.

According to existing literature, one relevant factor is teachers' professional identity and sense of connection to their school community. Teachers with a stronger professional identity and greater identification with their organization tend to have higher job satisfaction, commitment, and performance [10–12]. However, research on how organizational identity dimensions specifically relate to burnout in teachers is limited.

Another significant factor is the school environment and the perceived support from the administration. A study found that enabling school bureaucracy and psychological empowerment can play a role in mitigating teacher burnout [9]. On the other hand, Ford [13] discovered that when principals supported teachers' psychological needs at the intrapersonal, interpersonal, and organizational levels, it reduced teacher burnout and intent to leave, while increasing commitment. Gul et al. [14] suggested that an unconducive organizational culture with few growth opportunities increased teacher burnout and quitting.

Additionally, teachers' perceived locus of control, referring to their beliefs about control over life events, may influence their stress appraisals and coping strategies [14,15]. An internal locus of control has been associated with lower burnout, while an external locus of control tends to be linked to higher burnout [16,17]. Yet, the interrelationships between locus of control, organizational identity, and burnout in teachers remain unclear.

Sustainable teaching and learning for learners is part of the ingredients of quality of education. At the same time, it encapsulates how teachers sustained pedagogical practices with technology to motivate students based on multimodal learning. The actualization of Sustainable Development Goal 4, which concentrated on quality education for all, was severely affected by the COVID-19 pandemic. In the post-COVID-19 era, there is an intensified need to think of educational institutions without walls, another contemporary global issue such as teacher burnout affecting educators and its major implications for the quality of instruction students receive which can undermine the overall educational experience [9], and turn attention to the locus of control and organizational identity to decrease burnout and lack of motivation of teachers to overcome learning environment constraints.

This study sheds light on how locus of control and organizational identity can be applied to decrease burnout and lack of motivation of teachers to overcome learning environment constraints to promote sustainable teaching and learning in the education system.

This study aimed to address these gaps by examining how different aspects of organizational identity and internal–external locus of control relate to burnout dimensions among high school teachers. The specific research questions were:

RQ1: Do organizational identity dimensions (personal self-esteem, evaluative identification, self-classification as a teacher, professional identity, team identification, and emotional team membership) and internal–external locus of control affect burnout dimensions (emotional exhaustion, depersonalization, personal achievement) in teachers?

RQ2: Does internal–external locus of control mediate the relationship between organizational identity dimensions and burnout dimensions in teachers?

By providing insights into how identity, belonging, and control intersect to shape teacher burnout, this research can inform efforts to promote engagement and effectiveness among this critical segment of subject perceptions. The findings can also guide educational policymakers and school administrators in creating supportive environments that foster teacher well-being and resilience.

2. Literature Review

2.1. Burnout in Teachers

Burnout is a critical issue impacting teachers worldwide [18,19]. However, teachers face particular pressures that may exacerbate their risk of burnout [20]. Teachers must keep pace with rapidly advancing subject knowledge, implement hands-on instruction for practices, and ensure student competency in complex analytical skills [21]. They also often face large class sizes, insufficient lab facilities and supplies, and high-stakes assessments of student achievement [22–24]. These challenges can overwhelm teachers, depleting their energy and eroding their sense of efficacy. Indeed, existing research reveals concerning levels of burnout among teachers across many countries. Elementary teachers in Turkey display relatively low levels of emotional exhaustion, a core symptom of burnout [25]. According to a study conducted in the West Bengal state of India, teachers' burnout level is lower than their counterparts [26]. In China, surveys of teachers indicate that factors like age, gender, marital status, education, experience, and weekly work hours influence emotional exhaustion in teachers. Specifically, teachers aged 30–40, females, those with undergraduate degrees, those with 10–20 years of experience, and those working over 40 h weekly had higher exhaustion levels. Conversely, married/cohabiting teachers experienced less exhaustion than single or divorced/widowed/separated peers [27]. Burnout not only damages teachers' well-being, but it can also directly harm the quality of education. Studies link teacher burnout to lower job satisfaction, higher absenteeism, and inferior classroom practices [28,29]. Consequently, burnout has downstream impacts on students' motivation and achievement.

Given these high stakes, it is critical to identify protective factors against burnout specifically for teachers. The research on burnout in teachers points to several factors that can protect against burnout. Organizational climate and support seem to be key protective factors. Junça-Silva and Freire [30] found that an organizational climate characterized by involvement, control, autonomy, task orientation, and physical comfort reduced burnout in teachers. Professional development and skill-building may also help teachers avoid burnout. Kugiejko [31] proposed that developing teachers' professional skills and competence could prevent burnout. Work–life balance also appears to shield teachers from burnout [30,32]. In particular, learning strategies for managing student behavior, workload, and work responsibilities may equip teachers with the skills to handle job demands in a sustainable way. Mentorship and collegial support seem to be additional protective factors. Deswal and Savita [33] found that lack of support from colleagues contributed to burnout in teachers.

In summary, the research points to several protective factors against burnout in teachers: an autonomy-supportive organizational climate, work–life balance, professional development, and collegial support. By cultivating these protective factors, schools and policymakers may be able to support teachers' well-being and help prevent burnout.

2.2. Locus of Control

Locus of control refers to an individual's beliefs about the degree to which they have control over the outcomes of events in their lives [34]. Individuals with an internal locus of control believe that they have the power to influence events, while those with an external locus of control believe that events are largely determined by external factors. For educators, particularly teachers, the locus of control can have a significant influence on their teaching methods, classroom management, and interactions with students [35]. Research suggests that teachers with a more internal locus of control tend to have higher levels of self-efficacy and, consequently, more effective teaching practices [36,37]. In the realm of education, teachers' belief in their ability to control outcomes can influence how they approach classroom experiments, student inquiries, and the exploration of scientific phenomena. Teachers with an internal locus of control may believe that they have a significant influence over student behavior and learning outcomes. Teachers with a higher internal locus of control tend to employ more proactive classroom management

strategies [38]. This proactive approach can be particularly essential in classrooms where experiments and hands-on activities require structure and discipline. The locus of control among teachers plays a pivotal role in shaping their teaching methodologies, classroom management strategies, professional development attitudes, and interactions with students. Recognizing and addressing this psychological construct can be instrumental in fostering effective teaching and learning.

2.3. Organizational Identity

Organizational identity refers to how members define and experience the organization they work for [39]. It enables employees to feel a sense of belonging and emotional connection to the organization [40,41]. A strong organizational identity is associated with higher employee engagement, satisfaction, and performance [42–44]. Theoretical models describe organizational identity as emerging from the interplay between internal culture, external image, and member identification [45,46]. Internal organizational culture shapes identity by providing shared assumptions and values [42]. External images and reputations also influence identity by providing a social mirror [47,48]. Employees integrate these factors into a conceptualization of "who we are as an organization" [49]. The benefits of organizational identification are well established. High identification boosts cooperation, retention, and performance [50,51]. It also encourages extra-role behaviors that support organizational effectiveness [52,53]. However, potential downsides like resistance to change warrant consideration [54].

Teachers may experience unique dynamics related to their organizational identification. On one hand, the shared identity of being a "teacher" can create a strong sense of common purpose and subgroup distinctiveness [55]. Teachers often have specialized qualifications, expertise, and values rooted in the scientific method that bond them together [56]. However, identification with the broader school organization is also important to avoid isolation [57]. Teachers should feel their discipline is valued alongside others for a cohesive organizational culture [58,59]. Allowing teachers to participate in rituals and events beyond just the department will strengthen their organizational identity. Finding this balance between subject identity and organizational identity is key for effective schools. Overall, organizational identity represents a key driver of employee attitudes and behaviors. Both research and practice stand to benefit from the ongoing examination of antecedents, processes, and outcomes surrounding organizational identity. Leaders should leverage identity-affirming practices while remaining cognizant of potential identity tensions. A nuanced understanding of identity dynamics will allow organizations to maximize the benefits of member identification and commitment.

2.4. Relation among Organizational Identity, Locus of Control, and Burnout

These papers provide mixed evidence on the relationship between organizational identity, locus of control, and burnout. Two papers found a link between organizational identity and burnout. Lammers et al. [60] found that work group identification was associated with lower depersonalization, while professional identification was associated with increased personal accomplishment. Avanzi et al. [61] found that organizational identification led to less burnout through increased social support and collective efficacy. However, other papers found a more complex relationship. Jain et al. [62] found that locus of control and perceived organizational support moderated the relationship between job burnout and managerial effectiveness. When these moderators were high, the negative relationship between burnout and effectiveness was weaker. Elloy and Patil [63] found that organization-based self-esteem was negatively related to all three burnout dimensions.

Two papers examined how resources can buffer the negative impact of stressors on burnout. Day et al. [64] found that supervisor support and job control buffered the relationship between change stressors and exhaustion/cynicism. Job control also moderated the relationship between change and reduced professional efficacy. Avanzi et al. [61] found that social support and job control were associated with lower emotional exhaustion

through lower role stress. Emotional exhaustion then predicted depersonalization, lower professional commitment, and higher turnover intentions. There is a complex interplay between organizational identity, locus of control, and burnout in teachers. Teachers with an external locus of control, meaning they believe life events are outside their control, tend to experience higher burnout [14,16,65]. However, organizational identification, or a teacher's sense of belonging to their school, can mitigate the negative effects of external locus of control. When teachers strongly identify with their school, their external locus of control does not necessarily lead to burnout [66]. Job satisfaction also plays an important role in the relationship between organizational factors and burnout. Teachers who are more satisfied with their jobs tend to have lower burnout, even when facing significant stressors [67,68]. For student teachers in particular, job satisfaction mediates the connection between their professional identity and burnout [69]. Student teachers who are satisfied with their jobs are less likely to become burned out, even if they are still developing their professional identity.

Certain organizational stressors can also directly contribute to burnout in teachers. Lack of recognition and inadequate financial compensation are linked to lower job satisfaction and higher emotional exhaustion [68]. Perceived unfairness in organizational practices and policies leads to higher depersonalization and emotional exhaustion [70]. Heavy workloads, large class sizes, student misbehavior, and lack of input in decision-making are also associated with components of burnout like emotional exhaustion [22–24,67].

In summary, teachers' locus of control, organizational identification, job satisfaction, and exposure to organizational stressors all work together to influence their risk of burnout. Strong organizational identification and job satisfaction can help shield teachers from the negative impacts of external locus of control and high-stress work environments. By fostering supportive environments, fair policies, manageable workloads, and opportunities for input, schools may be able to promote teachers' well-being and prevent burnout.

3. Methodology

This study utilized a quantitative cross-sectional survey design to examine the research objectives. The study adopted cluster convenience sampling based on the five regions that the study covered in the northern part of Cyprus. The study sample consisted of 105 teachers from schools in five different regions in the northern part of Cyprus who agreed to complete the scale. The demographic information of the participants is shown in Table 1.

Table 1. Participants' Demographic Characteristics.

		f	(%)
Gender	Male	26	24.8
	Female	79	75.2
	Total	105	100
Age	18–25	75	71.4
	26–35	30	28.6
	Total	105	100
Total Working Duration	0–1 years	50	47.6
	1–5 years	37	35.2
	6 and above years	18	17.2
	Total	105	100
Education Level	Undergraduate	93	88.6
	Postgraduate	12	11.4
	Total	105	100

When the participants were analyzed in terms of demographics, it was determined that the majority of them were women (75.2%), between the ages of 18 and 25, their total service period was less than 1 year (47.6%), and their education level was undergraduate (88.6%). It is seen that the tenure of the majority of the participants in the school is more than 1 year (55.3%).

3.1. Data Collection Tools and Procedure

The "Personal Information Form", "Rotter Internal-External Locus of Control Scale", "Teacher Burnout Scale", and "Multiple Organizational Identity Scale" were used for the research. The data collection tools were approved by the Scientific Research Ethics Committee of the Near East University. Teachers from five different regions of the northern part of Cyprus were recruited to participate in the study, with an informed consent form to guarantee their withdrawal right, and the instrument was sent to the participants via a Google Form link to fill out the survey.

3.1.1. Rotter's Internal-External Locus of Control Scale

The Locus of Control Scale, introduced by Rotter in 1966 and later translated into Turkish [71], consists of 29 paired items designed to gauge the internal–external orientation of an individual. Of these, 6 items serve as fillers and do not factor into the final score. A few items are reverse-scored. The scale's internal consistency coefficient stands at 0.77, as cited by (1991). Rotter's External Locus of Control (RIELC) scores range from 0 to 23, with a higher score denoting a stronger external locus of control belief. Specifically, "A" options of items 2, 6, 7, 9, 16, 17, 18, 20, 21, 23, 25, and 29 earn 1 point each, as do "B" options for items 3, 4, 5, 10, 11, 12, 13, 15, 22, 26, and 28. This scoring method was confirmed [72].

3.1.2. Maslach Burnout Scale

The scale was developed by Maslach and Jackson and translated into Turkish [73]. The scale consists of three dimensions: emotional exhaustion, depersonalization, and personal accomplishment. There are 22 items in the 5-point Likert scale. While flat items scored between 1 and 5 are valid for emotional exhaustion and depersonalization, personal achievement items are scored in reverse [74]. Existing studies such as Gold [75], and Iwanicki and Schwab [76] confirmed the Cronbach's alpha value for emotional exhaustion as 0.90, depersonalization as 0.76, and personal accomplishment as 0.76, which are acceptable internal consistency values.

3.1.3. Multiple Organizational Identity Scale

Finally, the "Multiple Organizational Identity Scale" is a 6-point scale developed by [77], and the version that was adapted into Turkish [78] was used. The scale consists of 6 subdimensions: personal self-esteem, evaluative identification, self-classification as a teacher, emotional professional identity, team identification, and team membership. The internal consistency coefficients of the scale were determined as 0.78, 0.66, 0.96, 0.82, 0.67, and 0.72, respectively [78].

3.2. Data Analysis

This study utilized variance-based structural equation modeling (SEM) using SmartPLS 4 software to analyze the conceptual framework. PLS-SEM was chosen due to its ability to handle complex models with many constructs and indicators. The reflective measurement models were examined for adequate reliability and validity based on factor loadings, Cronbach's alpha, and average variance extracted (AVE). The formative measurement models were assessed for collinearity issues using variance inflation factors (VIF). A VIF threshold of 5 was adopted to check for multicollinearity. The PLS-SEM analysis included evaluating the structural model relationships based on path coefficients and their significance levels. The coefficient of determination (R2 value) was examined to assess the model's predictive power for the endogenous constructs. The effect size (f2) was calculated to determine the local effect of predictors. Multigroup comparison was conducted to uncover differences between novice and senior teachers as well as between male and female teachers. The path coefficients were compared between the two groups, and the statistical significance of the differences was tested. The mediating role of relational identification with students was analyzed by comparing the direct, indirect, and total effects between constructs. Bootstrapping was performed to determine the significance of mediation effects.

In summary, Smart-PLS 4 enabled testing of the conceptual framework through advanced PLS-SEM analysis. The software's extensive analytical capabilities were leveraged to comprehensively assess the measurement models, structural model relationships, predictive power, effect sizes, multigroup differences, and mediating effects to derive meaningful insights from the data.

4. Findings

4.1. Reflective Measurement Models

As recommended by Hair et al. [79], the measurement model analysis was performed to confirm the reliability and validity of all constructs. The results of the reliability of indicators showed that the outer loading of all indicators is greater than 0.7 [79], except for 5 items under burnout and 2 items under multiple organizational identity which were dropped as a result of poor loading values lesser than 0.6 based on the recommendation of Awang [80]. The composite reliability of constructs was >0.7, and the internal consistency values were higher than 0.7 [81,82], except for evaluative identification and team identification with values lesser than 0.7 but higher than 0.6 which are also acceptable Cronbach's alpha values [83], with acceptable composite reliability values. The AVE value of every construct was used to ascertain the convergent validity, and the values were greater than the 0.5 acceptable thresholds of Cheung and Wang [84] and Hair et al. [79]. In summary, the dimensions demonstrated sufficient reliability and validity to justify their inclusion for further analysis in Table 2.

Table 2. Factors Loading, Cronbach's Alpha, rho_a, rho_c, and AVE coefficients.

Dimensions	Items	Factor Loading	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Emotional Exhaustion	M_1	0.782	0.897	0.899	0.919	0.619
	M_2	0.808				
	M_3	0.806				
	M_6	0.783				
	M_8	0.838				
	M_13	0.741				
	M_16	0.747				
Depersonalization	M_5	0.744	0.800	0.811	0.87	0.627
	M_10	0.850				
	M_11	0.855				
	M_15	0.708				
Personal Accomplishment	M_12	0.816	0.731	0.745	0.846	0.647
	M_18	0.772				
	M_19	0.824				
Personal Self-Esteem	O_1	0.958	0.919	0.93	0.949	0.86
	O_2	0.918				
	O_3	0.906				
Self-Classification as a Teacher	O_6	0.940	0.657	0.854	0.841	0.729
	O_7	0.757				
Evaluative Identification	O_8	0.901	0.648	0.616	0.809	0.681
	O_9	0.742				
Emotional Professional Identity	O_10	0.773	0.895	0.906	0.923	0.707
	O_11	0.802				
	O_12	0.781				
	O_13	0.929				
	O_14	0.905				
Team Identification	O_15	0.922	0.659	0.689	0.807	0.68
	O_17	0.715				
Team Membership	O_18	0.887	0.700	0.703	0.869	0.769
	O_19	0.867				

The Fornell–Larcker criterion is a benchmark for evaluating discriminant validity in structural equation modeling. A proper review of the cross-loading table reveals that each latent variable demonstrated suitable discriminant validity. Specifically, the diagonal value for each construct, representing its correlation with itself, was consistently higher than its correlations (cross-loadings) with any other construct. For instance, Depersonalization (DP) exhibited a strong self-correlation of 0.792, with its highest cross-loading being 0.621 with Emotional Exhaustion (EE). Similarly, EE had a self-correlation of 0.787 and its primary interaction with DP was 0.621. This trend persisted across all constructs, such as Personal Accomplishment (PA) having a self-correlation of 0.804 and its most significant interaction with EE being −0.488. Notably, constructs like RIELC showcased perfect self-correlation with modest interactions with other constructs. The pattern reiterated the idea that each construct, from Evaluative Identification to Team Membership, held strong on its own without being overshadowed by potential overlaps with other constructs. Consequently, the results, based on the Fornell–Larcker criterion, endorse the discriminant validity of the constructs in the model as stated in Table 3.

Table 3. Fornell–Larcker Cross-Loading.

	DP	**EE**	**PA**	**RIELC**	**EPI**	**EI**	**PSE**	**SCT**	**TI**	**TM**
Depersonalization	0.792									
Emotional Exhaustion	0.621	0.787								
Personal Accomplishment	−0.252	−0.488	0.804							
RIELC	0.108	0.298	−0.259	1						
Emotional Professional Identity	−0.556	−0.642	0.556	−0.186	0.841					
Evaluative Identification	0.463	0.524	−0.317	−0.032	−0.566	0.825				
Personal Self-Esteem	−0.25	−0.265	0.483	−0.072	0.606	−0.252	0.927			
Self-Classification as a Teacher	−0.117	−0.13	0.242	−0.071	0.263	−0.104	0.473	0.854		
Team Identification	−0.444	−0.55	0.579	−0.274	0.601	−0.414	0.392	0.188	0.825	
Team Membership	−0.209	−0.215	0.378	−0.113	0.415	−0.137	0.543	0.301	0.39	0.877

The Heterotrait–Monotrait (HTMT) ratio offers another approach to assess discriminant validity. The HTMT values are interpreted against a common threshold (often recommended to be less than 0.85 or 0.90). According to the provided HTMT table, the relationships between constructs like Emotional Exhaustion (EE) and Depersonalization (DP) are at 0.728, which is below the typical threshold, suggesting that the constructs are indeed distinct. This is also the case for Personal Accomplishment (PA) with EE and DP, showing values of 0.586 and 0.323, respectively. Most of the values, such as those between RIELC and other constructs like Emotional Professional Identity (0.194) or Evaluative Identification (0.05), are considerably below the threshold, further supporting their discriminant validity. However, some ratios, like that between Team Identification and PA (0.825), come close to the upper end of the threshold, implying that the distinction between these constructs might be carefully evaluated. Overall, most of the constructs in the table have HTMT values below the Ringle et al. [85] and Henseler, Ringle, and Sarstedt [86] recommended acceptable threshold, bolstering the evidence of adequate discriminant validity between the majority of the constructs in the model as stated in Table 4.

Table 4. Heterotrait–Monotrait ratio (HTMT).

	DP	EE	PA	RIELC	EPI	EI	PSE	SCT	TI	TM
Depersonalization										
Emotional Exhaustion	0.728									
Personal Accomplishment	0.323	0.586								
RIELC	0.113	0.314	0.313							
Emotional Professional Identity	0.646	0.701	0.669	0.194						
Evaluative Identification	0.678	0.723	0.453	0.05	0.82					
Personal Self-Esteem	0.28	0.283	0.569	0.074	0.673	0.352				
Self-Classification as a Teacher	0.162	0.189	0.336	0.099	0.364	0.198	0.595			
Team Identification	0.629	0.74	0.825	0.332	0.776	0.757	0.469	0.28		
Team Membership	0.28	0.276	0.501	0.133	0.531	0.22	0.676	0.439	0.508	

4.2. Formative Measurement

The quality of the formative measurement models is evaluated by looking at collinearity issues within the formative indicators.

The Variance Inflation Factor (VIF) provides insight into the extent of multicollinearity between independent variables in a regression model. Typically, a VIF value exceeding 10 is seen as a strong indication of multicollinearity, while values above 5 might raise concerns in some research contexts [87]. Examining the presented table, it is evident that all VIF values are well below these thresholds. The constructs RIELC, Emotional Professional Identity, Evaluative Identification, Personal Self-Esteem, Self-Classification as a Teacher, Team Identification, and Team Membership have VIF values ranging from 1.138 to 2.693 when considered against the predictor constructs DP, EE, PA, and RIELC. Specifically, as stated in Table 5 Emotional Professional Identity displays the highest VIF at 2.693, while RIELC has the lowest with 1.138. Though some constructs like Emotional Professional Identity and Personal Self-Esteem have VIF values on the higher end relative to others, all are within acceptable limits. Consequently, there is no substantial evidence of multicollinearity issues among the examined constructs based on the provided VIF table.

Table 5. VIF values.

Dimension	DP	EE	PA	RIELC
RIELC	1.138	1.138	1.138	
Emotional Professional Identity	2.693	2.693	2.693	2.636
Evaluative Identification	1.610	1.61	1.610	1.54
Personal Self-Esteem	2.209	2.209	2.209	2.187
Self-Classification as a Teacher	1.297	1.297	1.297	1.295
Team Identification	1.754	1.754	1.754	1.661
Team Membership	1.520	1.520	1.520	1.520

Table 6 elucidates the relationships between various constructs by presenting path coefficients and their statistical significance. The T-statistic and corresponding *p*-values allow us to determine the significance of these relationships. For the path from RIELC to Emotional Exhaustion (EE), there is a significant positive relationship with a path coefficient of 0.178 ($p = 0.014$). Conversely, the relationship for the path from Emotional Professional Identity to Depersonalization (DP) and EE is significantly negative, with coefficients of

−0.429 (p = 0.017) and −0.462 (p < 0.001), respectively. Evaluative Identification also exhibits a significant positive influence on EE with a coefficient of 0.227 (p = 0.006) and a significant negative influence on RIELC with a coefficient of −0.248 (p = 0.039) as stated in Table 6.

Team Identification's relationship with EE and PA is negative and positive, respectively, and both are statistically significant (p = 0.026 for EE and p = 0.018 for PA). The path from Team Identification to RIELC also showcases a significant negative relationship (p = 0.009).

Not all relationships are significant. For instance, the paths from RIELC to DP and PA, from Emotional Professional Identity to PA and RIELC, and various paths associated with Evaluative Identification, Personal Self-Esteem, Self-Classification as a Teacher, and Team Membership do not reach conventional levels of significance.

It is also noteworthy that while the paths from some constructs like Emotional Professional Identity are prominently influential (with coefficients like −0.429 and −0.462), others like those of Self-Classification as a Teacher have very minimal influence (coefficients close to 0). This variety underlines the differential strengths and significance of relationships among the explored constructs.

Table 6. Path Coefficients.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p*-Values
RIELC -> DP	0.000	0.014	0.082	0.001	0.999
RIELC -> EE	0.178	0.17	0.072	2.466	0.014
RIELC -> PA	−0.116	−0.104	0.071	1.636	0.102
emotional professional identity -> DP	−0.429	−0.407	0.18	2.386	0.017
emotional professional identity -> EE	−0.462	−0.456	0.127	3.646	0
emotional professional identity -> PA	0.177	0.195	0.13	1.363	0.173
emotional professional identity -> RIELC	−0.224	−0.236	0.147	1.528	0.127
evaluative identification -> DP	0.187	0.187	0.134	1.396	0.163
evaluative identification -> EE	0.227	0.23	0.082	2.771	0.006
evaluative identification -> PA	−0.025	−0.032	0.111	0.224	0.823
evaluative identification -> RIELC	−0.248	−0.23	0.12	2.06	0.039
personal self-esteem -> DP	0.131	0.106	0.166	0.786	0.432
personal self-esteem -> EE	0.157	0.129	0.113	1.391	0.164
personal self-esteem -> PA	0.2	0.191	0.105	1.907	0.057
personal self-esteem -> RIELC	0.137	0.152	0.134	1.024	0.306
self-classification as a teacher -> DP	−0.014	−0.022	0.119	0.116	0.908
self-classification as a teacher -> EE	−0.017	−0.006	0.092	0.18	0.857
self-classification as a teacher -> PA	0.014	0.022	0.085	0.161	0.872
self-classification as a teacher -> RIELC	−0.048	−0.056	0.143	0.337	0.736
team identification -> DP	−0.152	−0.162	0.113	1.346	0.178
team identification -> EE	−0.198	−0.194	0.089	2.226	0.026
team identification -> PA	0.331	0.323	0.14	2.363	0.018
team identification -> RIELC	−0.285	−0.274	0.109	2.618	0.009
team membership -> DP	−0.013	0.006	0.113	0.113	0.91
team membership -> EE	0.024	0.041	0.133	0.181	0.856
team membership -> PA	0.046	0.048	0.083	0.556	0.578
team membership -> RIELC	−0.003	−0.008	0.105	0.027	0.979

The total effects table provides a comprehensive understanding of the direct and indirect influences of various constructs on one another. For each path, we can determine

its significance based on the T-statistic and corresponding *p*-values. The relationship between RIELC and Emotional Exhaustion (EE) emerges as statistically significant, with a path coefficient of 0.178 ($p = 0.014$). On the other hand, Emotional Professional Identity's influence on Depersonalization (DP) and EE is notably negative, with coefficients of -0.429 ($p = 0.011$) and -0.502 ($p < 0.001$), respectively. This suggests that as Emotional Professional Identity increases, the values of DP and EE tend to decrease.

Evaluative Identification exerts a significant positive influence on EE (coefficient = 0.183, $p = 0.027$) and a notable negative influence on RIELC (coefficient = -0.248, $p = 0.039$). This indicates divergent effects of Evaluative Identification on these constructs.

The paths related to Team Identification are worth highlighting. Team Identification showcases a negative relationship with both DP and EE (coefficients of -0.152 and -0.249, respectively) with the path to EE being significant ($p = 0.007$). Additionally, it displays a robust positive effect on Personal Accomplishment (PA) with a coefficient of 0.364 ($p = 0.01$) and a significant negative relationship with RIELC ($p = 0.009$).

However, it is important to acknowledge several non-significant paths. For instance, the relationships involving Self-Classification as a Teacher and Team Membership with other constructs mostly do not meet the conventional significance threshold.

In essence, while certain constructs, such as Emotional Professional Identity and Team Identification, manifest clear and often significant relationships with others, several paths remain non-significant, underscoring the varied influences in the model as stated in Table 7.

4.3. Mediating Effect of RIELC

A mediator essentially works to explain the mechanism through which one variable influences another. For RIELC to serve as a mediator, it needs to influence both the independent variable(s) and the dependent variable(s). The path from Emotional Professional Identity to RIELC: The path coefficient for Emotional Professional Identity's effect on RIELC is -0.224 with a *p*-value of 0.127. Even though this effect is negative, it is not statistically significant based on conventional standards ($p < 0.05$). Paths from RIELC to DP, EE, and PA: The coefficients for RIELC's influence on DP, EE, and PA are 0, 0.178, and -0.116, respectively. Only the path to EE is significant ($p = 0.014$). This suggests that RIELC significantly influences Emotional Exhaustion (EE) but does not have a statistically significant influence on Depersonalization (DP) or Personal Accomplishment (PA).

We compared the direct paths from the Path Coefficient table to the Total Coefficients. Emotional Professional Identity to DP: The direct effect is -0.429 (significant) while the total effect, which includes the mediating effect of RIELC, is -0.414 (still significant). This suggests that the inclusion of RIELC as a mediator has slightly reduced the negative influence of Emotional Professional Identity on DP, but this mediating effect is not strong. Emotional Professional Identity to EE: The direct effect is -0.462 (significant) while the total effect is -0.502 (still significant). This indicates that when considering RIELC as a mediator, the negative relationship between Emotional Professional Identity and EE becomes slightly stronger. Emotional Professional Identity to PA: The direct effect is 0.177 (not significant), and the total effect is 0.203 (not significant). The relationship remains non-significant with the mediation of RIELC. RIELC has a potential mediating effect on the relationship between Emotional Professional Identity and EE. The mediation appears to slightly strengthen the negative relationship between the two constructs. For the paths involving DP and PA, the mediating effect of RIELC is not clearly observed based on the provided coefficients. In conclusion, RIELC may play a mediating role, especially in the relationship between Emotional Professional Identity and Emotional Exhaustion.

The R-square values provide a measure of how well the observed outcomes are replicated by the model, based on the proportion of total variation of outcomes explained by the model.

For the Depersonalization (DP) variable, the original sample's R-square is 0.365, indicating that the model explains 36.5% of the variance in DP. This is confirmed to be statistically significant with a T-statistic of 3.792 and a *p*-value of 0. The adjusted R-square,

which takes into account the number of predictors in the model, is slightly lower at 0.319. Emotional Exhaustion (EE) has an original R-square of 0.533, meaning the model accounts for 53.3% of the variance in EE. This is supported by a significant T-statistic of 6.376 and a *p*-value of 0. The adjusted R-square is 0.499. For Personal Accomplishment (PA), the model explains 44.5% of its variance as indicated by the original R-square of 0.445. This is statistically significant with a T-statistic of 6.343 and a *p*-value of 0. The adjusted R-square is slightly lower at 0.405. Lastly, RIELC has a lower R-square value of 0.121, suggesting that the model explains 12.1% of the variance in RIELC. This is marginally significant with a T-statistic of 1.987 and a *p*-value of 0.047. However, when we consider the adjusted R-square, which stands at 0.068, the significance drops with a *p*-value of 0.297, suggesting that when taking into account the number of predictors, the model may not be a very robust fit for explaining the variance in RIELC.

Table 7. Path Coefficients for Total Effect.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p*-Values
RIELC -> DP	0.000	0.014	0.082	0.001	0.999
RIELC -> EE	0.178	0.17	0.072	2.466	0.014
RIELC -> PA	−0.116	−0.104	0.071	1.636	0.102
emotional professional identity -> DP	−0.429	−0.414	0.169	2.544	0.011
emotional professional identity -> EE	−0.502	−0.498	0.119	4.227	0
emotional professional identity -> PA	0.203	0.22	0.129	1.574	0.116
emotional professional identity -> RIELC	−0.224	−0.236	0.147	1.528	0.127
evaluative identification -> DP	0.187	0.186	0.129	1.452	0.147
evaluative identification -> EE	0.183	0.193	0.083	2.208	0.027
evaluative identification -> PA	0.004	−0.007	0.11	0.033	0.973
evaluative identification -> RIELC	−0.248	−0.23	0.12	2.06	0.039
personal self-esteem -> DP	0.131	0.11	0.161	0.813	0.416
personal self-esteem -> EE	0.182	0.156	0.118	1.536	0.125
personal self-esteem -> PA	0.184	0.177	0.106	1.73	0.084
personal self-esteem -> RIELC	0.137	0.152	0.134	1.024	0.306
self-classification as a teacher -> DP	−0.014	−0.019	0.119	0.117	0.907
self-classification as a teacher -> EE	−0.025	−0.014	0.097	0.259	0.796
self-classification as a teacher -> PA	0.019	0.027	0.087	0.22	0.826
self-classification as a teacher -> RIELC	−0.048	−0.056	0.143	0.337	0.736
team identification -> DP	−0.152	−0.164	0.116	1.314	0.189
team identification -> EE	−0.249	−0.241	0.092	2.697	0.007
team identification -> PA	0.364	0.353	0.141	2.583	0.01
team identification -> RIELC	−0.285	−0.274	0.109	2.618	0.009
team membership -> DP	−0.013	0.004	0.113	0.114	0.91
team membership -> EE	0.023	0.04	0.138	0.17	0.865
team membership -> PA	0.047	0.048	0.087	0.538	0.591
team membership -> RIELC	−0.003	−0.008	0.105	0.027	0.979

The f-square value measures the effect size, or the local impact of a predictor on an endogenous construct, within a structural model. A larger f-square value suggests a greater effect size.

RIELC's effect on: DP is negligible with an f-square value of 0, which is confirmed as non-significant with a *p*-value of 1. EE shows a small effect size with an f-square of 0.06, but this is not statistically significant with a *p*-value of 0.239. PA also has a small effect

size (f-square = 0.021) and is not statistically significant (p = 0.431). Emotional Professional Identity's impact on: DP is moderate (f-square = 0.108) but not significant (p = 0.325). EE has a more substantial effect size (f-square = 0.169) but still lacks statistical significance (p = 0.179). PA shows a small effect size (f-square = 0.021) and is not significant (p = 0.605). RIELC is similarly small (f-square = 0.022) and non-significant (p = 0.516). Evaluative Identification's influence on: DP is minor (f-square = 0.034) and non-significant (p = 0.58). EE shows a slightly more considerable effect (f-square = 0.069) but remains non-significant (p = 0.214). PA is negligible (f-square = 0.001) and non-significant (p = 0.975). RIELC's effect size is small (f-square = 0.045) and not significant (p = 0.309). The effect sizes for Personal Self-Esteem, Self-Classification as a Teacher, Team Identification, and Team Membership are mostly small across all endogenous constructs, and none of them are statistically significant based on their respective p-values as stated in Table 8.

4.4. Multigroup Analyses

Novice vs. Senior Teacher

Table 9 compares path coefficients between predictors and outcomes for novice and senior teachers. For the RIELC -> PA path, novices show a positive coefficient while seniors have a negative coefficient. This difference is statistically significant (p = 0.029). The emotional professional identity -> PA path is positive and significant for novices (p = 0.000) but near zero and non-significant for seniors. This difference is significant (p = 0.029). The personal self-esteem -> PA path is negative for novices but positive and significant for seniors (p = 0.024). The between-group difference is significant (p = 0.007). The personal self-esteem -> RIELC path is positive and significant for novices (p = 0.004) but negative and non-significant for seniors. This difference is statistically significant (p = 0.007). For the team identification -> EE path, novices have a negative non-significant coefficient while seniors have a stronger negative and significant coefficient (p = 0.037). However, the between-group difference is non-significant. Similarly, the team identification -> RIELC path is negative for novices but more strongly negative and significant for seniors (p = 0.027), though the between-group difference is not significant. In summary, RIELC, emotional professional identity, personal self-esteem, and team identification relate differently to outcomes for novice versus senior teachers. Seniors appear less influenced by professional identity and self-esteem but more by team factors. Further exploration of these differences is warranted. This finding revealed that teachers' perceptions of sustainable digital environments are one of the motivation factors to set digital learning ecology for learners. Overcoming learning environment constraints with the support of technology also supports institutional identity and learning in the workplace, therefore overcoming burnout rates and motivation on locus of control.

Table 8. R-square and Adjusted R-square.

	R-Square					**Adjusted R-Square**
	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	***p*-Values**	**Original Sample (O)**
DP	0.365	0.426	0.096	3.792	0	0.319
EE	0.533	0.573	0.084	6.376	0	0.499
PA	0.445	0.493	0.07	6.343	0	0.405
RIELC	0.121	0.172	0.061	1.987	0.047	0.068

According to Table 10, Table 11 compares path coefficients between predictors and outcomes for females versus males. For the RIELC -> EE path, females show a positive and significant coefficient (0.188, p = 0.03) while males show a smaller, positive but non-significant coefficient (0.048, p = 0.733). The emotional professional identity -> DP path is negative and significant for females (-0.463, p = 0.022) but non-significant for males despite

a higher negative coefficient (−0.681, $p = 0.124$). The emotional professional identity -> EE path is strongly negative and significant for females (−0.612, $p = 0$) but weaker and non-significant for males (−0.219, $p = 0.66$). The personal self-esteem -> PA path is positive and significant for females (0.311, $p = 0.014$) but negative and non-significant for males (−0.153, $p = 0.743$). The team identification -> EE path is negative but non-significant for females (−0.091, $p = 0.308$) versus stronger, negative, and significant for males (−0.639, $p = 0.049$). The team identification -> PA path is positive and significant for females (0.403, $p = 0.014$) but near zero and non-significant for males (−0.025, $p = 0.949$). The team identification -> RIELC path is negative and significant for females (−0.317, $p = 0.012$) but negative and non-significant for males (−0.137, $p = 0.75$). In summary, predictors like RIELC, emotional professional identity, personal self-esteem, and team identification relate differently to outcomes for females versus males. Females appear more influenced by identity and self-esteem factors while males are more affected by team factors. These gender differences warrant further investigation.

Table 9. F-square values.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p*-Values
RIELC -> DP	0	0.01	0.014	0	1
RIELC -> EE	0.06	0.066	0.051	1.178	0.239
RIELC -> PA	0.021	0.026	0.027	0.787	0.431
emotional professional identity -> DP	0.108	0.128	0.109	0.985	0.325
emotional professional identity -> EE	0.169	0.196	0.126	1.345	0.179
emotional professional identity -> PA	0.021	0.039	0.041	0.517	0.605
emotional professional identity -> RIELC	0.022	0.033	0.033	0.65	0.516
evaluative identification -> DP	0.034	0.056	0.062	0.553	0.58
evaluative identification -> EE	0.069	0.083	0.055	1.243	0.214
evaluative identification -> PA	0.001	0.016	0.022	0.031	0.975
evaluative identification -> RIELC	0.045	0.05	0.045	1.018	0.309
personal self-esteem -> DP	0.012	0.03	0.041	0.299	0.765
personal self-esteem -> EE	0.024	0.03	0.034	0.699	0.485
personal self-esteem -> PA	0.033	0.041	0.039	0.843	0.399
personal self-esteem -> RIELC	0.01	0.021	0.025	0.391	0.696
self-classification as a teacher -> DP	0	0.019	0.028	0.008	0.993
self-classification as a teacher -> EE	0	0.015	0.022	0.021	0.983
self-classification as a teacher -> PA	0	0.011	0.017	0.015	0.988
self-classification as a teacher -> RIELC	0.002	0.021	0.029	0.071	0.943
team identification -> DP	0.021	0.036	0.04	0.523	0.601
team identification -> EE	0.048	0.056	0.045	1.054	0.292
team identification -> PA	0.113	0.141	0.12	0.94	0.347
team identification -> RIELC	0.056	0.06	0.045	1.226	0.22
team membership -> DP	0	0.013	0.019	0.009	0.993
team membership -> EE	0.001	0.026	0.038	0.021	0.983
team membership -> PA	0.003	0.01	0.014	0.177	0.859
team membership -> RIELC	0	0.008	0.011	0.001	1

Table 10. Comparison Path Coefficients of Novice and Senior Teachers.

Path	Original (Novice)	Mean (Novice)	STDEV (Novice)	t-Value (Novice)	*p*-Value (Novice)	Original (Senior)	Mean (Senior)	STDEV (Senior)	t-Value (Senior)	*p*-Value (Senior)	Novice vs. Senior *p*-Value
RIELC -> DP	−0.028	−0.027	0.133	0.211	0.833	−0.056	−0.027	0.108	0.514	0.608	0.438
RIELC -> EE	0.017	0.017	0.145	0.114	0.909	0.114	0.099	0.1	1.14	0.254	0.71
RIELC -> PA	0.171	0.167	0.109	1.572	0.116	−0.15	−0.119	0.132	1.133	0.257	0.029
emotional professional identity -> DP	−0.466	−0.471	0.267	1.743	0.081	−0.449	−0.417	0.293	1.532	0.126	0.531
emotional professional identity -> EE	−0.635	−0.62	0.24	2.647	0.008	−0.528	−0.492	0.227	2.327	0.02	0.626
emotional professional identity -> PA	0.614	0.608	0.175	3.506	0	0.073	0.099	0.234	0.311	0.756	0.029
emotional professional identity -> RIELC	−0.701	−0.658	0.214	3.271	0.001	−0.046	−0.056	0.204	0.224	0.823	0.982
evaluative identification -> DP	0.345	0.313	0.23	1.503	0.133	0.067	0.064	0.199	0.335	0.738	0.172
evaluative identification -> EE	0.192	0.2	0.19	1.007	0.314	0.185	0.192	0.125	1.486	0.137	0.48
evaluative identification -> PA	0.191	0.154	0.174	1.098	0.272	−0.14	−0.126	0.186	0.753	0.451	0.097
evaluative identification -> RIELC	−0.323	−0.297	0.179	1.806	0.071	−0.354	−0.306	0.237	1.494	0.135	0.431
personal self-esteem -> DP	0.349	0.314	0.285	1.224	0.221	0.064	0.017	0.239	0.267	0.789	0.218
personal self-esteem -> EE	0.429	0.362	0.247	1.733	0.083	0.005	−0.038	0.145	0.034	0.973	0.075
personal self-esteem -> PA	−0.147	−0.149	0.225	0.654	0.513	0.316	0.307	0.14	2.259	0.024	0.964
personal self-esteem -> RIELC	0.652	0.628	0.229	2.852	0.004	−0.088	−0.077	0.182	0.482	0.63	0.007
self-classification as a teacher -> DP	−0.085	−0.109	0.182	0.467	0.64	0.033	0.01	0.139	0.238	0.812	0.702
self-classification as a teacher -> EE	−0.229	−0.2	0.206	1.112	0.266	0.039	0.03	0.111	0.352	0.725	0.875
self-classification as a teacher -> PA	0.114	0.123	0.157	0.729	0.466	0.088	0.088	0.151	0.586	0.558	0.448
self-classification as a teacher -> RIELC	−0.35	−0.352	0.161	2.18	0.029	0.087	0.052	0.206	0.419	0.675	0.947
team identification -> DP	−0.052	−0.088	0.148	0.352	0.725	−0.239	−0.241	0.191	1.251	0.211	0.216
team identification -> EE	−0.085	−0.074	0.132	0.645	0.519	−0.32	−0.321	0.153	2.088	0.037	0.118
team identification -> PA	0.47	0.448	0.171	2.748	0.006	0.203	0.197	0.214	0.951	0.342	0.167
team identification -> RIELC	−0.094	−0.075	0.164	0.572	0.567	−0.419	−0.386	0.189	2.216	0.027	0.094
team membership -> DP	0.077	0.083	0.165	0.47	0.638	−0.105	−0.05	0.208	0.505	0.614	0.236
team membership -> EE	−0.092	−0.064	0.224	0.411	0.681	0.232	0.246	0.133	1.749	0.08	0.892
team membership -> PA	0.032	0.039	0.151	0.211	0.833	0.064	0.072	0.148	0.434	0.664	0.56
team membership -> RIELC	−0.099	−0.118	0.167	0.592	0.554	0.075	0.083	0.194	0.388	0.698	0.754

Table 11. Comparison Path Coefficients of Female and Male Teachers.

	Original (Female)	Mean (Female)	STDEV (Female)	t-Value (Female)	*p*-Value (Female)	Original (Male)	Mean (Male)	STDEV (Male)	t-Value (Male)	*p*-Value (Male)	(Female vs. Male) *p*-Value
RIELC -> DP	−0.024	−0.002	0.103	0.23	0.818	0.033	0.04	0.155	0.211	0.833	0.612
RIELC -> EE	0.188	0.183	0.087	2.171	0.03	0.048	0.054	0.142	0.341	0.733	0.183
RIELC -> PA	−0.128	−0.12	0.078	1.655	0.098	−0.121	−0.1	0.202	0.6	0.548	0.514
emotional professional identity -> DP	−0.463	−0.426	0.202	2.296	0.022	−0.681	−0.645	0.443	1.538	0.124	0.302
emotional professional identity -> EE	−0.612	−0.595	0.108	5.666	0	−0.219	−0.26	0.497	0.44	0.66	0.78
emotional professional identity -> PA	0.216	0.231	0.124	1.746	0.081	0.302	0.473	0.541	0.557	0.577	0.526
emotional professional identity -> RIELC	−0.243	−0.257	0.162	1.503	0.133	−0.369	−0.483	0.469	0.786	0.432	0.396
evaluative identification -> DP	0.09	0.082	0.148	0.605	0.545	0.258	0.271	0.255	1.014	0.311	0.744
evaluative identification -> EE	0.19	0.196	0.082	2.305	0.021	0.343	0.337	0.256	1.341	0.18	0.754
evaluative identification -> PA	0.07	0.051	0.108	0.646	0.518	−0.262	−0.139	0.369	0.709	0.478	0.208
evaluative identification -> RIELC	−0.281	−0.239	0.15	1.872	0.061	−0.241	−0.251	0.341	0.706	0.48	0.543
personal self-esteem -> DP	0.128	0.067	0.214	0.597	0.551	0.653	0.599	0.391	1.669	0.095	0.9
personal self-esteem -> EE	0.008	−0.01	0.114	0.075	0.94	0.44	0.452	0.384	1.146	0.252	0.887
personal self-esteem -> PA	0.311	0.301	0.127	2.451	0.014	−0.153	−0.299	0.468	0.327	0.743	0.15
personal self-esteem -> RIELC	0.03	0.066	0.175	0.174	0.862	0.31	0.388	0.423	0.734	0.463	0.75
self-classification as a teacher -> DP	−0.107	−0.116	0.152	0.703	0.482	0.055	0.061	0.203	0.273	0.785	0.747
self-classification as a teacher -> EE	0.03	0.023	0.083	0.36	0.719	0.033	−0.017	0.245	0.133	0.894	0.524
self-classification as a teacher -> PA	−0.091	−0.093	0.106	0.86	0.39	0.499	0.506	0.275	1.813	0.07	0.976
self-classification as a teacher -> RIELC	−0.118	−0.142	0.183	0.646	0.518	0.289	0.318	0.292	0.991	0.322	0.884
team identification -> DP	−0.122	−0.136	0.137	0.892	0.372	−0.604	−0.546	0.326	1.853	0.064	0.076
team identification -> EE	−0.091	−0.089	0.089	1.02	0.308	−0.639	−0.558	0.325	1.965	0.049	0.045
team identification -> PA	0.403	0.382	0.164	2.457	0.014	−0.025	0.067	0.4	0.063	0.949	0.153
team identification -> RIELC	−0.317	−0.293	0.126	2.516	0.012	−0.137	−0.119	0.429	0.319	0.75	0.682
team membership -> DP	−0.116	−0.065	0.167	0.693	0.488	0.325	0.275	0.273	1.19	0.234	0.928
team membership -> EE	0.141	0.149	0.113	1.249	0.212	0.059	0.044	0.356	0.165	0.869	0.401
team membership -> PA	−0.046	−0.031	0.125	0.372	0.71	0.041	−0.021	0.344	0.12	0.905	0.622
team membership -> RIELC	0.151	0.126	0.159	0.955	0.34	−0.354	−0.345	0.308	1.149	0.25	0.055

5. Discussion

The results of this study provide several notable insights into how reflective learning, emotional professional identity, evaluative identification, self-esteem, self-classification, and team factors relate to teacher burnout dimensions and relational identification with students.

Firstly, the external locus of control was found to have a significant positive relationship with emotional exhaustion. This aligns with past research which has repeatedly shown that teachers with a more external locus of control, meaning they believe life events are outside of their personal control, tend to experience higher levels of burnout [14,65]. For example, [14] found that an external locus of control was the strongest predictor of emotional exhaustion in their sample of Italian high school teachers. They hypothesized that teachers with an external locus are more likely to appraise demands as threatening and deplete their coping resources faster. Similarly, [65] found that Turkish elementary teachers with an internal locus of control had lower levels of emotional exhaustion and depersonalization. In another study conducted by [88] in China, teachers have been urged to see themselves as dynamic agents, maintain their sense of control, reinforce their professional competence, and identify.

The findings in this study provide further confirmation that an external locus of control constitutes a risk factor making teachers more vulnerable to core aspects of burnout like exhaustion. Teachers with an external locus are more prone to stress and helplessness in the face of classroom challenges, student misbehaviors, workload pressures, and other demands. They may feel incapable of influencing negative events or outcomes [16]. This sense of powerlessness can gradually drain their emotional energy and enthusiasm. Conversely, teachers with a more internal locus of control seem to be buffered against burnout. An internal locus provides resilience against demands by promoting a belief in one's ability to shape events and exert control.

This study's findings point to the value of providing resources and training to help strengthen teachers' internal locus of control. For instance, professional development focused on proactive classroom management, relationship-building with students, and effective coping strategies could bolster internal control beliefs. Ongoing social–emotional support from colleagues and administrators is also important. Ultimately, fostering an internal locus of control could empower teachers to manage the daily challenges of their demanding profession.

Secondly, this study found that emotional professional identity had robust negative effects on two core dimensions of teacher burnout—depersonalization and emotional exhaustion. This aligns with previous research suggesting that organizational identification can protect against burnout in teachers. For example, [61] found that teacher identification with their school was associated with lower emotional exhaustion and depersonalization. They proposed social support and collective efficacy as mediators of this relationship. Similarly, [89] found that organizational identification moderated the negative relationship between job stressors and burnout, acting as a buffer.

The findings from this study provide further evidence that emotional professional identity, meaning teachers' affective connection and sense of belonging to their role, can safeguard their well-being and prevent burnout symptoms. Teachers who strongly identify with their professional role are intrinsically motivated, finding meaning and purpose in their work [89–91]. This provides resilience against exhausting demands and disconnected, uncaring attitudes towards students.

Fostering emotional professional identity among teachers early on, such as during teacher training programs, may be beneficial. Allowing pre-service teachers to observe classrooms, assist with lessons, and discuss challenges with experienced teachers helps socialize them into their professional role. This process of identity construction continues during student teaching placements. Once in the field, ongoing professional development focused on values, ethics, and the broader purpose of education can further cultivate professional identity.

Additionally, administrators and colleagues should actively affirm teachers' professional identities through recognition, esteem-building, and fueling passion for the meaningful impacts they have on students' lives. A strong emotional connection to one's work seems to be a vital component protecting teachers from disengagement, exhaustion, and cynicism.

Thirdly, this study found differences between novice and senior teachers in terms of which factors influenced their burnout. For novice teachers, emotional professional identity and self-esteem were more impactful. However, for senior teachers, team identification and support were more relevant. This aligns with past research suggesting that teachers' needs and experiences differ across career stages. Early-career teachers relied more on intrinsic motivators like professional identity, while late-career teachers depended more on school-level factors like leadership [92–94]. This finding provides insight into why such differences emerge. Early-career teachers may still be actively developing their new professional identity and establishing self-efficacy. Senior teachers likely have their identity internalized, so peer collaboration becomes more pivotal. As teachers gain experience, identity components that previously buffered stress may become taken for granted. Senior teachers may then rely more on external resources like team belongingness.

This has implications for supporting teachers' well-being. During the novice stage, identity-affirming practices are essential—e.g., seminars on ethics and dispositions, mentorship programs, and autobiographical reflections. For seniors, creating collaborative time with colleagues is impactful. Tailoring initiatives based on career stage can ensure that teachers receive the support most relevant to them. Additionally, the transition between early and late career appears to be an important point of vulnerability. Teachers may need extra assistance in shifting sources of motivation and support. Bridging programs that allow novice teachers to integrate into collaborative teacher teams could smooth this career transition. Overall, this finding provides valuable insight into evolving experiences underlying progression through the teaching career. It points to the need to offer stage-specific support attuned to teachers' developmental needs.

Finally, this study found gender differences in how organizational factors relate to teacher burnout. For female teachers, personal identity components like self-esteem and emotional professional identity were more impactful. However, for male teachers, team identification and membership were more influential. This aligns with previous research revealing gender disparities in teacher burnout. For instance, Antoniou et al. [95] found that female teachers reported higher emotional exhaustion than males. They suggested that socialization practices encourage women to be more emotionally expressive.

This finding from this study helps provide insight into potential mechanisms underlying gender differences in burnout among teachers. Female teachers may rely more on internal resources like self-concept and professional identity to manage demands. Males may depend more on external resources like collegial support systems. This has important implications for supporting teacher well-being in a gender-sensitive way. For female teachers, identity-affirming practices that boost self-efficacy and recharge passion for teaching may be most beneficial. For males, initiatives fostering collaborative teamwork and peer support may have the greatest impact. Additionally, gender inclusion training for administrators could help ensure that organizational practices do not perpetuate traditional social roles and stereotypes. Creating space for both task-oriented and socioemotional interactions could allow all teachers to access a full range of coping resources. Overall, this finding builds upon existing knowledge of gender dynamics in teacher stress and burnout. It points to the value of accounting for gender differences when designing initiatives to support teacher well-being, belongingness, and burnout prevention.

Overall, this study's findings reveal valuable insights into the complex interplay of organizational factors in shaping teacher burnout. The association between external locus of control and exhaustion highlights the importance of bolstering teachers' internal control beliefs. The protective capacity of emotional professional identity points to the value of identity-affirming practices for buffering against burnout. Differences based on experience suggest the need to tailor support to teachers' evolving developmental needs. Finally,

gender disparities uncovered reveal the necessity of gender-sensitive initiatives catered to the unique pressures faced by male and female educators. Overall, a nuanced understanding of how identity, control beliefs, career stage, and gender intersect to influence teacher well-being can guide targeted efforts to foster engaging, healthy school environments. By implementing support attuned to these dynamics, educators' invaluable contributions can be sustained over the long term.

6. Conclusions and Recommendations

This study explored how external locus of control, professional identity, self-esteem, and team factors relate to burnout dimensions and student connectedness among teachers. Several key conclusions can be drawn:

Firstly, external locus of control may have unintended consequences, with findings showing it can exacerbate emotional exhaustion. Schools should thus be thoughtful in how reflective practices are implemented and ensure that adequate support systems are in place. Secondly, emotional professional identity emerges as an important buffer against depersonalization and emotional exhaustion. Fostering this identity from early teacher training and into professional service can potentially safeguard teacher well-being. Additionally, differences exist between novice and senior teachers, with identity and self-esteem more relevant for novices while team aspects are more impactful for experienced teachers. Administrators should account for this when devising initiatives at each career stage. Finally, variations occur across genders, with identity and self-esteem factors more salient for females and team dynamics more influential for males. Teacher policies should acknowledge that well-being needs likely differ between genders.

This study contributes preliminary evidence on how individual, relational, and organizational factors intersect to shape teacher burnout and connectivity with students. Further research across diverse settings can help substantiate these findings and inform policies that promote teacher effectiveness. Overall, a nuanced approach accounting for experience level and gender is required to optimize teachers' psychological health and professional thrive. The study relied on self-report surveys to measure locus of control, identity, and burnout. This can introduce subjectivity and social desirability biases. More objective measures could complement self-reports. The study focused only on organizational identity, locus of control, and burnout. Including other relevant variables like leadership, professional development, and work overload could provide a more comprehensive picture.

This study supported the concept that technology and digital tools in learning environments need to be used for skill acquisition and motivation for both students and teachers in their institutions. Furthermore, learning models, theories, and pedagogical practices need to be investigated in detail to shed further recommendations for designing and implementing digital technology for sustainable teaching and learning.

7. Implication and Limitations

This study has established that educators, school administrators, and education policymakers should consider the effect of reflective practices to guarantee suitable support systems for teachers since the external locus of control can have unintended consequences like exacerbation of emotional exhaustion. Teacher training curricula should be structured to foster emotional professional identity from early teacher training and into professional service that can potentially safeguard teacher well-being. On a cautious note, it is important to consider the limitations of this study before the application of its findings. This study applied a quantitative research method with only 105 teachers from schools in five different regions of the northern part of Cyprus. It is also important to note that more female teachers participated in the study compared to their male counterparts. The diverse cultural dimensions that exist between these five regions might have an impact on the findings of this study and did not consider comparative analysis responses. Using an online survey for data collection might also affect the participant's readiness to take part in the study because teachers with low digital competence levels may decide not to participate due to

"digiphobia". However, these limitations should not serve as a hindrance to the application of its results in other contexts.

Author Contributions: Conceptualization, B.B. and Z.A.; methodology, Z.A.; software, B.B.; validation, B.B.; formal analysis, B.B.; investigation, B.B.; resources, Z.A.; data curation, Z.A.; writing—original draft preparation, B.B.; writing—review and editing, Z.A.; visualization, Z.A.; supervision, Z.A.; project administration, Z.A.; funding acquisition, B.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with and approved by the Ethics Committee of Near East University.

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

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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Cultural Heritage for Sustainable Education Amidst Digitalisation

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Abstract: The integration of cultural heritage in education facilitates critical thinking, experiential learning, cross-cultural collaborative learning and ultimately, quality learning experiences. This process is further enhanced by the increasing adoption of digital technology, which makes education more accessible. However, some countries in the European Union have low digital literacy and a high student dropout rate. Also, the use of cultural heritage in education is declining as young learners are becoming increasingly unaware of their cultural identity. Within this framework, a study of mixed methods (questionnaires and interviews) was conducted in three European countries to examine digital and cultural heritage competencies among young learners. The results of the paper reveal how digital cultural heritage increases learners' resilience by promoting competences for digital transformation, which in turn enhances learning and engagement with cultural heritage. Drawing on our findings, the paper proposes a new innovative hybrid model within the framework of sustainable education (SE).

Keywords: sustainability; cultural heritage; digitalisation; skills; education; hybrid teaching; sustainable education; sustainable learning

Citation: Orphanidou, Y.; Efthymiou, L.; Panayiotou, G. Cultural Heritage for Sustainable Education Amidst Digitalisation. *Sustainability* **2024**, *16*, 1540. https://doi.org/10.3390/su16041540

Academic Editors: Rustam Shadiev, Barry Lee Reynolds and Rui Li

Received: 24 November 2023
Revised: 6 February 2024
Accepted: 7 February 2024
Published: 11 February 2024

1. Introduction

1.1. Research Context

The current article explores how the embracement of cultural heritage in education through the adoption of digital technology can cultivate learners' skills and further contribute to sustainable education (Figure 1). Sustainable education (SE) refers to teaching and learning practices, skills and strategies which facilitate lifelong learning inside and outside the classroom [1]. According to Doukanari et al. [2], "research on sustainable education examines a wide range of learning practices, methods, and strategies, and how they consider, adapt to, and meet the diverse needs of student cohorts" (2021:1). The authors explain how SE has gradually expanded to comprise a wide range of practices and strategies, varying from sustainable feedback, students' sustainable development, problem-solving and hands-on experiences through to field trips, inter-disciplinary learning, internationalisation, sustainable curricula metrics, Multicultural Teamwork (MMT), Case-based Learning (CBL) and Problem-based Learning (PBL), among others.

According to Sterling [3], sustainable education (SE) can achieve an essential cultural shift. Cultural heritage learning fosters respect and understanding for cultural diversity, promotes intercultural discussion and contributes to more resilient and inclusive communities [4–6]. Cultural heritage refers to behaviours, beliefs, habits and artefacts that are passed down from generation to generation, forming a community's or society's identity. History, architecture, art, music, literature and language are all included, as are traditional knowledge, rituals and festivals [7]. Cultural heritage not only provides individuals and communities with a sense of pride and identity, but it also plays an important role in promoting intercultural discourse, protecting biodiversity and developing social cohesion.

Cultural heritage includes tangible cultural heritage and intangible cultural heritage. Tangible cultural heritage refers to physical artefacts created, maintained and passed down through generations in a civilisation. Intangible cultural heritage has been defined by UNESCO [8] as "the practices, representations, expressions, knowledge, and skills-as well as the instruments, objects, artefacts, and cultural spaces associated with them-that communities, groups, and, in some cases, individuals recognise as part of their Cultural Heritage". Oral traditions, performing arts, local knowledge and traditional skills are examples of intangible heritage.

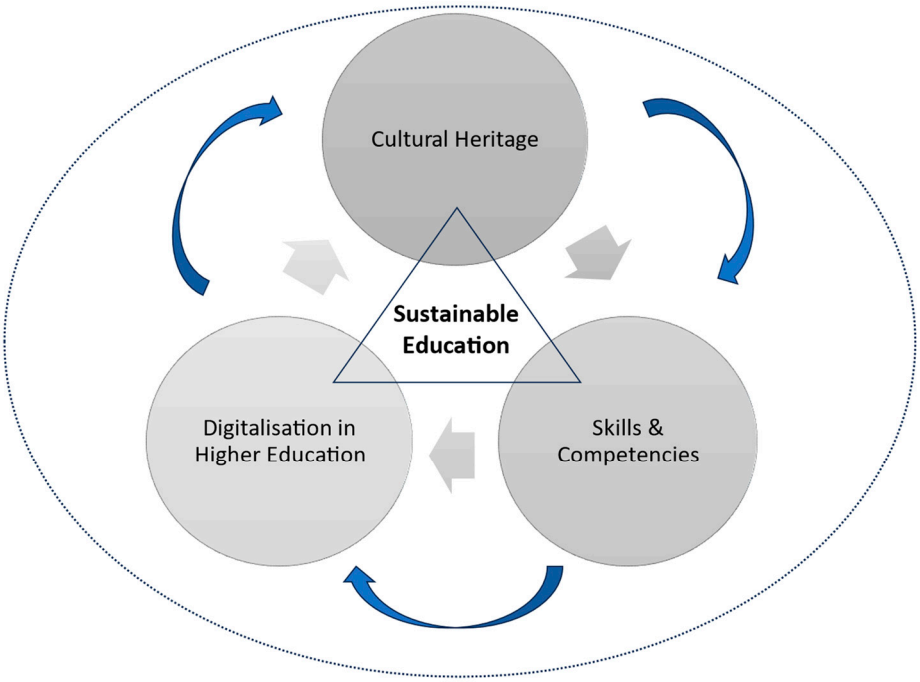

Figure 1. Literature review at the intersection of cultural heritage, skills and digitalisation as part of SE.

Within the framework of the Sustainable Development Goals (SDGs), set by the United Nations 2030 Agenda, it is critical to maintain and conserve cultural heritage for future generations to ensure its sustainability and relevance in an ever-changing world [9]. In light of increasing globalisation, cultural heritage began to decline. Young people became increasingly unaware of their cultural identity [10]. But lately, cultural heritage has gained popularity, along with public and scholarly interest around the world. Its conceptual reach can be seen in various Erasmus+ projects [11]. Also, cultural heritage is linked to urban sustainability [12]; preservation and revitalisation; experiences [13]; city regeneration [14]; and sustainable development [15], among others. Social scientists emphasise its functions in promoting ethnic, national and elite interests, while others highlight its creative and counter-hegemonic aspects. Promoting Education for Sustainable Development (ESD) in pursuit of the Sustainable Development Goals (SDGs) will strengthen collaboration with diverse sectors, particularly culture and science, to smoothly integrate ESD into the 2030 agenda. One main goal of ESD is to empower youth, prepare them to face the contemporary difficulties of unsustainable development and prepare them to be future decision makers. An aspect of the current study seeks to understand the level of youth awareness, attitudes and practices regarding tangible and intangible cultural heritage.

Moreover, as presented in Figure 1, the links between sustainable education, skills and cultural heritage are further enhanced by the increasing adoption of digital technology in education [16–19]. The inner set of arrows in the figure represent the interconnection and interdependence among the different components of sustainability. The outer set of arrows exists on the periphery of interdependence and reveals a dynamic in which the three

components are further enhanced and reinforced as part of a perpetual sustainability cycle. Individual skills and abilities can be strengthened through digitally aided education and training. The Institute for Prospective Technological Studies (IPTS), one of the European Commission's Joint Research Centres, has compiled a comprehensive study of national approaches to digital education policy around the world [20]. Recognising the importance of digital skills at the time, the European Parliament and Council of the European Union named digital competence as one of eight core competences required for lifelong (and sustainable) learning in 2006 [21]. Since then, the EU has developed numerous Digital Competence Frameworks (Dig Comp, DigCompEdu, DigCompOrg) to assist with the development of digital skills among all citizens, educators, educational organisations and consumers (DigCompConsumers). Four proficiency levels in five domains were developed, letting people evaluate their own digital skills and allowing comparisons between member states [22]:

a. Information and data literacy;
b. Communication and cooperation;
c. Creation of digital material;
d. Safety, and;
e. Problem solving.

Human, digital and soft skills are more important in the twenty-first century than cognitive skills. They encompass abilities that robots and artificial intelligence lack or do not thrive on, but that people do have [23,24]. Learners with such talents will be in high demand since they can design and progress digital transformation [25], as well as contribute to societal advancement and innovation in general. Furthermore, the ability to manage change, notably resilience, adaptation, leadership and flexibility, is an important long-term ability for cultivating preparation for future advances [26]. In 2021, the European Union member nations had the lowest proportions of early school leavers. In contrast and contradiction with this, Italy (13%) and Cyprus (10%) reported the highest percentages. The EU member states have set themselves a target to reduce the rates of early school leavers to below 9% as the EU-level target by 2030. Sixteen member states have already met this EU-level target for 2030 for this indicator, including Lithuania [27].

The term "digital native" is increasingly being used in public discourse to describe generations of young people who have grown up surrounded by digital technologies. The term implies that young people intuitively understand how to use technology and thus do not require digital education or training. All EU digital policies during the last decade, including the Digital Agenda for Europe (2010) [28], the Digital Single Market for Europe (2015) [29] and a Europe fit for the digital age (2020) [30], have intended to make every European digitally competent. Although research on young people's usage of the Internet and technology in Council of Europe member countries is scant, Eurostat data provide some insight into the situation in the European Union. Consequently, 95% of young Europeans in 2021 aged 16–29 years reported using the Internet every day. However, the percentage of young people with a basic or advanced level of digital skills varies between 46% and 93%, with an EU average of 71%. Performing basic computer tasks, such as copying or moving a file or folder, is something, according to Eurostat [31], that 76% of all young people can do.

The use of digital technology has increased dramatically over the previous two decades. Digital technology is defined as "the use of electronic equipment to store, generate, or analyse data, as well as to promote communication and virtual interactions on social media platforms via the internet" [32]. Laptops, smartphones, computers, tablets and other similar devices are all considered electronic gadgets that are utilised for interpersonal connection, virtual communication and virtual engagement. Of course, research should consider not only the positive impact of technology but also its negative implications. Social media has swiftly changed the way young learners communicate with one another, igniting considerable scientific and public discussion over its possible impact on young learners socioemotional well-being and mental health. The necessity to bridge this knowledge gap has become more obvious in view of the COVID-19 pandemic [33]. For example,

Borthwick et al. [34] and Kumar et al. [35] state that "[l]earners can download the necessary information or upload their content using a plethora of digital resources". Web 2.0 tools (wikis, podcasts, blogs and so on) enable learners to create material, collaborate with others, evaluate each other's work and progress toward co-learning. The pandemic has forced people to rely on digital networks to preserve socio-emotional connections [36]. At the same time, most existing jobs will become obsolete due to technological advancements, and employees will require re-skilling and upskilling to expand their competencies and remain employed [37]. The use of technology and digital means in the education system has become increasingly important and necessary in order to meet the changing needs of students and provide them with a high-quality education that is accessible, flexible and sustainable [38].

1.2. Research Gap, Scope and Contribution

The current article is part of the growing literature in the field of sustainable education (SE). The framework of SE does not solely contribute to sustainability and sustainable development. SE is a theoretical body on its own, which comprises a set of learning strategies, practices and pedagogies [2]. Adding further to the framework of SE, this is the first study to explore the interconnection of cultural heritage, skills and digitalisation and how they contribute to SE, as illustrated in Figure 1.

Also, the literature review revealed a need to explore additional learning methodologies for young learners. Even though young learners are progressively recognised as the fundamental stakeholders in the educational system, the vast majority of educational research continues to focus entirely on learners' viewpoints, positioning learners as passive information providers [39–41]. Young learners are more likely to be digital natives, meaning they grew up with technology and are more comfortable using it. Digital skills have implications for the future of the European workforce [42]. In an increasingly digital economy, those with strong digital skills will have a competitive advantage in the job market, whereas youth who lack such skills will find themselves in a position of disadvantage [22,25].

Drawing on the findings collected through mixed methods, this paper contributes to the literature with a new conceptual learning model, utilising tangible and intangible cultural heritage and emphasising the influence of digital cultural heritage as part of sustainable education. As outlined in the recommendations of the European Commission and the European Council [43], the introduction of this new innovative e-learning model that connects cultural heritage with digital skills is a new learning methodology that reflects the needs of digital native learners, with the aim of developing disciplinary and life skills and improving learners' key competences. This e-learning pathway can motivate learners and teens who are in danger of dropping out of school because it changes their understanding of and enthusiasm for digital technologies, such as social media and video games. In addition, the model considers the different needs, skills and competences of learners while adapting to their age, level of knowledge and abilities.

2. Research Design and Methodology

The research study was conducted in three European countries, Cyprus, Italy and Lithuania, between the years 2021 and 2023. The countries participating in the study were selected due to their striking similarity in terms of dropout rates, in line with the study's aim, which is to examine countries with low digital literacy and a high percentage of dropouts. Extensive secondary research was conducted to conceptualise the study by applying the method of a critical review [44]. The study included an in-depth examination of education curricula, national reports, European data from Eurostat, publications by the European Commission, the OECD and the Partnership for 21st Century Skills, and UNESCO studies. The purpose was to gather sufficient information on the three countries and their local educational systems and to demonstrate the extent to which education curricula have embraced cultural heritage elements. In terms of primary research, the study applied mixed research methods.

Questionnaires were used to gain a deeper understanding of young learners' digital and cultural heritage competencies. This quantitative approach was selected due to the need to measure the attitudes, opinions and characteristics of a large sample [45,46] and the need to collect a large amount of quantitative data from a sizeable sample [47,48]. The research population was composed of youth in private and public schools in Cyprus, Italy and Lithuania, as well as learners in tertiary education and youngsters that had dropped out of formal education and were more vulnerable in the labour market. An online structured self-administered questionnaire consisting of fifteen questions was used to gather data, covering areas such as demographics, familiarity with digital means and level of competence in relation to cultural heritage. The study adopted probability sampling. The sample was drawn from each institution's list of learners (sampling frame). The collection of quantitative data was conducted online through Google Forms. The questionnaire link was shared by each institution participating in the study. In total, 820 questionnaires were collected. The responses were analysed through SPSS (Statistical Package for the Social Sciences, Version 21). The questionnaire is available in the Supplementary Material (Questionnaire S1).

To avoid biased responses and to alleviate respondents' concerns or reluctance to participate in the current survey, the respondents were assured in advance that information generated from completed questionnaires would be anonymous and completely confidential and would be used only for the academic purposes of the current investigation. A cover statement on Google Forms aimed to explain to the respondents the research topic, aim and objectives, so that they could understand the crucial importance of their contribution prior to agreeing to respond to the questionnaire.

Also, interviews were conducted to ascertain the views of key stakeholders. The interviews' participants were key stakeholder representatives, including museum officers, policymakers and education authorities. The fieldwork's aim was to grasp the opinions of different authorities who have a role to play at the intersection of cultural heritage, digitalisation and education, and more specifically, with regard to the skills and competencies that future graduates should be equipped with. The interview method was used to facilitate the exchange of information between the researcher and the respondents since the research question required a detailed analysis on the part of the interviewees and thus demanded a method capable of providing in-depth and exhaustive information. Interviews were therefore deemed the most suitable method since they provided interviewees with plenty of freedom to articulate their thoughts and present their opinions. In the qualitative part of the research, purposeful sampling was applied since this technique is commonly used in qualitative research and allows for the optimum use of limited resources [49]. This entails locating and selecting individuals or groups of individuals who are particularly knowledgeable about or experienced with the phenomenon of interest [50]. Twenty-one (21) semi-structured interviews were conducted with educators, policymakers and representatives of cultural identities from the three selected countries. The interviews were conducted in native languages and translated into English (which is the project's official language) by the project's designated translator.

The interviews were analysed manually through two-cycle coding [51], as presented in Table 1 below. The criteria used for coding are the 13 competencies that appear in Figure 2 later in the analysis. As mentioned earlier, the purpose was to explore the preferences of different authorities with regard to the skills and competencies that future graduates should be equipped with. The first cycle of coding included a review of field notes. This process was undertaken immediately after each interview using a "data-set sheet". Reviewing the findings right away was helpful in recalling information that may have slipped the note-taking during a fast discussion. The first cycle included categorising and labelling officias' responses. It was also about formulating an interpretation since different authorities had different expectations about the skills and competencies expected from future graduates and employees. In other words, the process was about interpreting expressions and synthesising multiple sentences, which then became small sentences.

Table 1. Phases of two-cycle coding and meta-coding.

	Phases
1st-Cycle Coding	- Undertaken immediately after each interview using a "data-set sheet" - Review of field notes - Categorising and labelling official responses - Formulating interpretations - Developing small sentences
2nd-Cycle Coding	- Further analysis and re-organisation of material - Synthesisation of sentences into paragraphs
Meta-Coding	- Development of longer, analytical pieces of text - Integration of paragraphs into the article's analysable units. - Linking of analysis back to theory

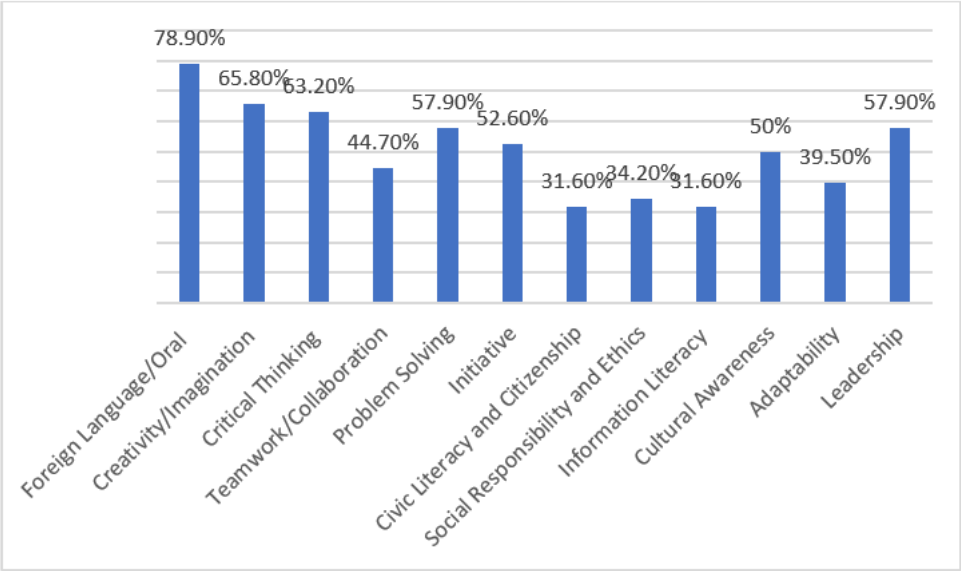

Figure 2. Competences' importance in enhancing employability.

Then, the second-cycle coding enabled the researchers to re-analyse, re-organise and resynthesise the material produced through the first-cycle coding to produce bigger chunks of analysis. Then, the "meta-code" method [52] was employed to develop longer, analytical pieces of text to be integrated into the article's analysable units. Towards the end of the study, when a substantial part of the article was written, the second-cycle phase became redundant. It was replaced by "meta-coding", which included direct editing of the article's analysis. Throughout the research collection process, the findings were linked back to theory and are presented in the "Findings" section below.

Since the study was undertaken as part of an EU-funded project, research ethics approval was granted by the project consortium's legal office. The collection of findings through interviews and questionnaires applied international research ethics principles and tools, including informed consent, anonymity, confidentiality and data privacy. The participants (for interviews) and respondents (for questionnaires) were provided with a cover letter explaining the aims and objectives of the study, along with potential benefits for education.

Finally, the use of mixed methods allowed the researchers to fully explore the status of the competence of youth in digital cultural heritage and the readiness of current education and cultural providers to deliver digital cultural heritage education, focusing on enhancing the skills and competences of young Europeans to enhance their employability and entrepreneurial capability.

3. Data Analysis and Results

The questionnaire sample consisted of 239 questionnaires from Cyprus, 458 questionnaires from Italy and 123 questionnaires from Lithuania. The gender representation of the sample was 50.3% female and 48.1% male. The sample that responded was equally distributed between the genders, with a slight predominance of the female gender. Most of the respondents resided in their country of origin, with insignificant percentages attributed to other origins. The largest percentage of respondents belonged to the 14–16 age group (58.8% of the sample), followed by the 17–19 age group (41.1%), and lower percentages are to be found for the 20–25 and 26–30 age groups. Furthermore, 87% of the sample had primary-to-secondary education, with 2.4% representing dropouts and 7.3% having university education. Finally, only 3% of people had pursued but never completed university education.

3.1. Competencies and Digital Means

The first part of the questions aimed to identify the competencies that the young respondents valued as most important. The survey's respondents had to select from a list of thirteen competencies that had been identified as the most important ones by the OECD, the European Commission and the Partnership for 21st Century Skills [53]. As presented in Figure 2, the data analysis revealed that foreign languages (78.9), creativity (65.8) and critical thinking (63.2) were valued as the top three important competences for enhancing employability, with problem solving and leadership following at 57.9%. All thirteen competencies had a significant percentage of 30% or above, which indicates equal importance. The replies of the young respondents reveal a high level of awareness of the competencies they need to possess to enhance their employability (see Figure 2).

As the research focuses on digital natives' skills, it was important to identify what type of digital devices young people use most often. Smartphones are by far the most commonly used digital device among young people, with 98.9% of the sample selecting them as their first choice. Second in line are laptops and PCs at 44.9%, followed by tablets at 28.3%. The Mascheroni and Cuman [54] study supports that in European countries, young people go online using multiple devices. It has been determined that young people prefer to use the web for social networking, gaming, and chatting [55]. Overall, young people today use a wide range of digital devices for a variety of purposes, and the types of devices they use can vary depending on many socioeconomic and cultural characteristics.

Due to the need for a larger screen and more powerful processing, young people frequently use laptops and tablets for studying, gaming and other activities. Wearable tech, smartwatches and other wearable devices are becoming more popular among young people for communication, fitness tracking and other uses. While older teens (aged 17–19) preferred laptops and desktops, the younger respondents (aged 14–16) appeared to be more likely to use tablets or smartphones.

The advancement in technology, and especially the introduction of social media such as Facebook and Instagram, which affect the way we live, work and, more importantly, learn, have changed people's lives dramatically. Teachers and professors are increasingly incorporating social media into their classes, whether they are online or in person, to engage students and advance their knowledge. Changing pedagogical approaches and implementing new teaching strategies, organising and controlling learning, and accessing important information sources have all benefited from a technology-enhanced learning environment [56–59]. In summary, social media is affecting and moulding how young learners' study and interact today, and many educational institutions and organisations have developed online courses and e-learning platforms that provide educational content in a variety of formats, such as video lectures, online quizzes, and interactive activities. The data analysis showed that among users between the ages of 14 and 19 who utilise digital methods to access learning and general information, 73.5% of the overall sample ranked YouTube as their top option (see Figure 3), with this being consistent with the most comfortable platform used for learning (see Figure 4). It is extremely intriguing that

e-books and PowerPoint presentations, which are widely used in formal education, are not preferred digital media for people between the ages of 14 and 30 (see Figures 3 and 4). A significant result of this research was the requirement to redesign pedagogical frameworks for online learning in education.

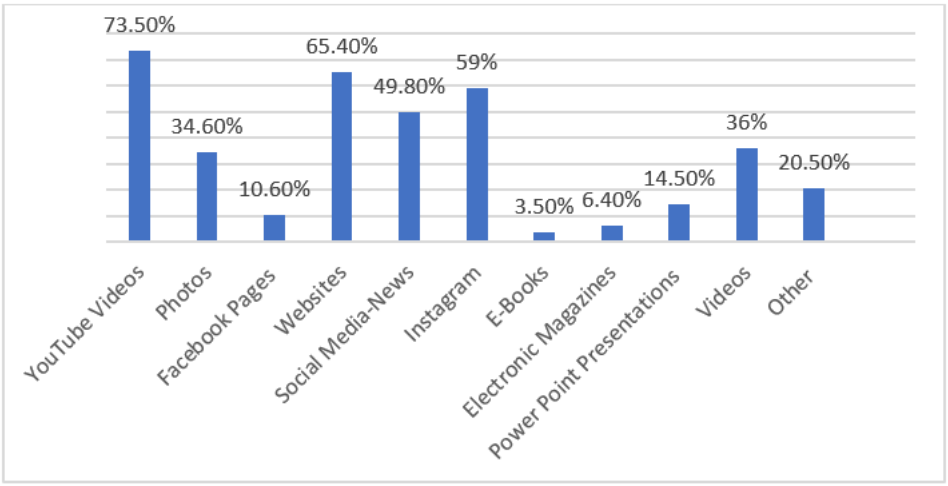

Figure 3. Use of digital means for learning and information purposes.

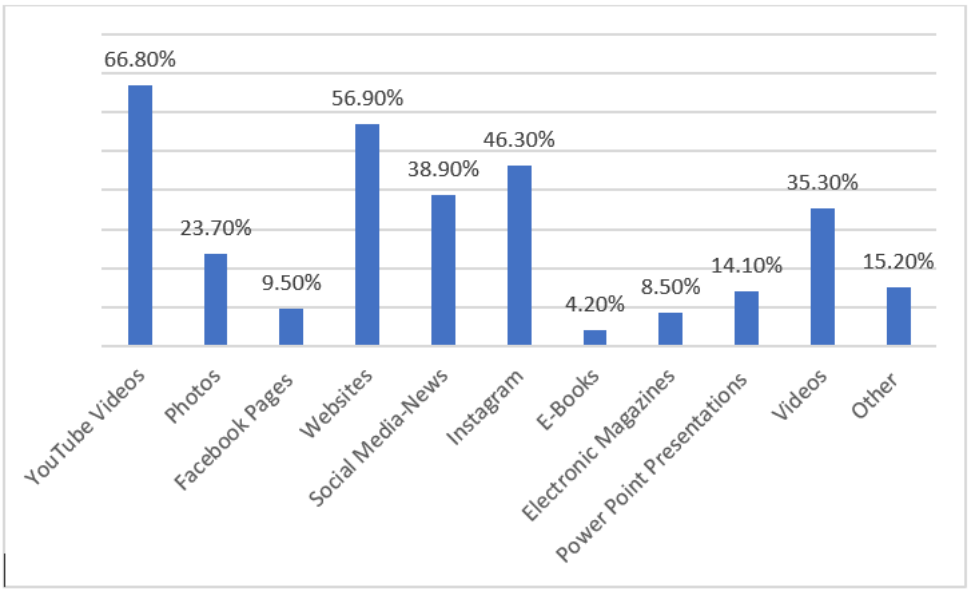

Figure 4. Digital tools learners feel more comfortable using in learning.

3.2. Cultural Heritage

As described in the Introduction, UNESCO [7] classifies cultural heritage into three types: tangible, intangible and natural. An evaluation of the literature suggests that cultural heritage is an important component of our cognitive knowledge [60] and should be taught in schools. In the 1990s, Bruner [61] and Wertsch [62] wrote stirring papers on the tradition of cultural psychology, stressing the fact that culture is entirely fabricated and that it shapes and allows the functioning of the human mind. Their view was that learning and thinking always occur in specific cultural contexts. "Culture shapes the mind of an individual. Its individual expression is achieved through the creation of meaning, through the attribution of meaning to things in different contexts and situations" [63]. Among the aims of this study was to determine how knowledgeable the young respondents were about tangible and intangible heritage.

As presented in Figure 5, there is a lack of awareness around both tangible and intangible cultural heritage since the respondents struggled to identify all nine of the assessed cases as cultural heritage. From the whole sample of respondents in the study, only 30% identified the nine assessed cases as most relevant to tangible and intangible cultural heritage. The study's findings confirm the importance of emphasising cultural heritage in curricula because failing to do so puts pride and respect for European identity in jeopardy.

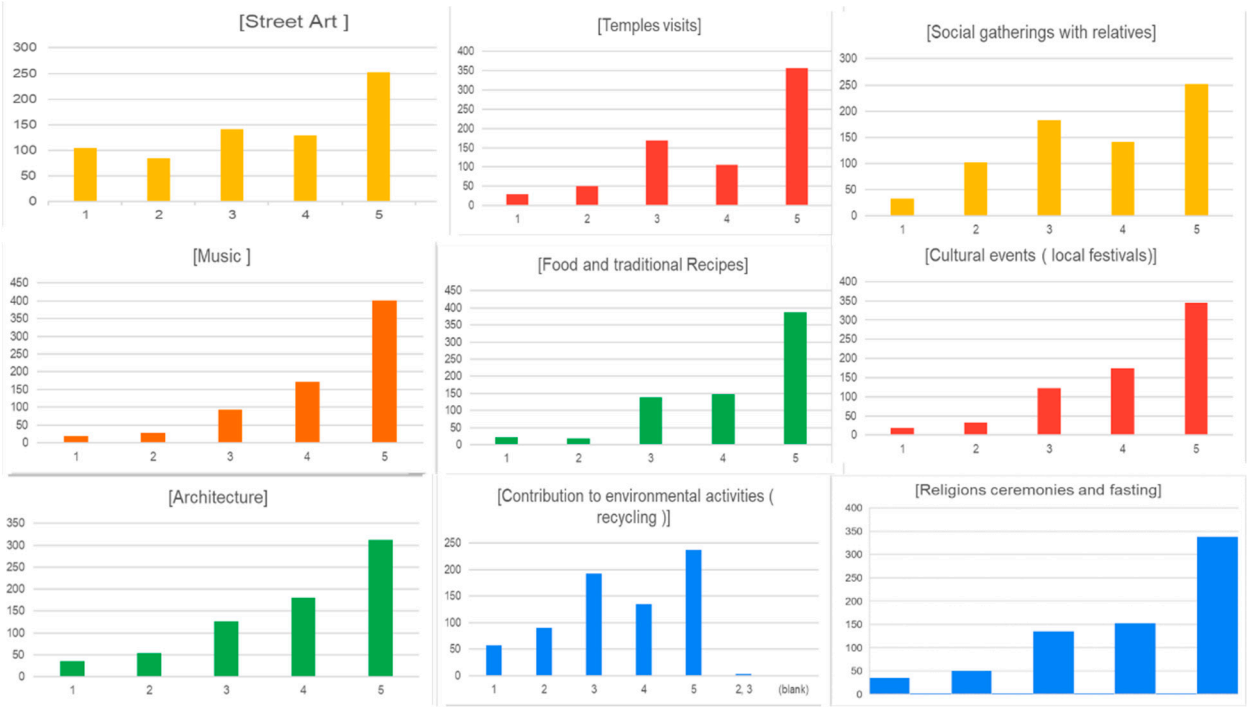

Figure 5. Identify the following examples in relation to cultural heritage, with 1 being least relevant and 5 being most relevant.

3.3. Education and Digital Cultural Heritage

The interviews provided a significant data pool, as the interviewees were purposefully selected to represent education and cultural providers in the three countries. From the analysis of the data collected, there is a consensus in so far as the way cultural heritage is taught in primary education, which involves mostly courses such as music, art, geography and religion. In secondary education, there is an emphasis on languages, history, economics and civic education. There is, however, a significant gap in how education systems define cultural heritage. From one country and language to another, the terms "culture", "cultural heritage" and "education" were not defined in the same way. There was agreement that "cultural legacy", which includes both tangible and intangible elements, has an impact on both the past and the present.

From the interview scripts' content analysis, there was a strong agreement that heritage and education should be seen as tools for sustainable development rather than just a reaction to the market-based economy. "Cultural heritage is not a "duty" or an encounter with heritage, but a tool that in the right hands can give good results" [11]. Within this context, it is imperative that education, including its primary objectives and strategies, be re-considered, including issues pertaining to digital cultural heritage education. The use of digital cultural heritage education may enhance the development of soft skills and competencies necessary to create resilience in European youth.

We can also increase learners' resilience in the cultural sector by holding various thematic workshops in open spaces (e.g., museums, archaeological parks, nature parks, national parks). "Workshops will affect the acquisition of knowledge and skills, or their

consolidation, and thus learners will be more resilient". Cultural heritage education thus enhances people's ability to become not only fulfilled citizens able to live in society but also responsible citizens regarding the protection of cultural heritage. The use of digital cultural heritage education may help to improve the soft skills and competencies required to generate resilience in European youth. "Learning about belonging to our society and community access is a must as well as for our cultural identity in order to promote social engagement and active participation in society".

From the interviewees' analysis, the authors gathered very strong statements that support the need for the utilisation of cultural heritage in education curricula. The respondents' repetitive feedback on the benefits of using cultural heritage in education provides a strong basis regarding the need for a new pedagogical model.

4. Discussion

4.1. Innovative Hybrid Educational Model

SE cannot become fully sustainable without integrating aspects of cultural heritage into the learning process. The current paper suggests a "Digicult" model (Figure 6), which emphasises the use of cultural assets in the learning experience to improve learners' skills and competencies. The name "Digicult" comprises the word's digitalisation and culture. Based on this model, learners develop information, intellectual abilities and a broader variety of competences on themes such as cultural heritage maintenance and societal well-being by actively experiencing or analysing elements of cultural heritage. This type of knowledge leads to long-term economic growth initiatives, including chances for respectable work. The suggested model ensures inclusiveness for young learners aged 14–30 while taking into consideration various educational backgrounds and motivating them to engage in lifelong learning. The model is appropriate for formal, non-formal and informal education.

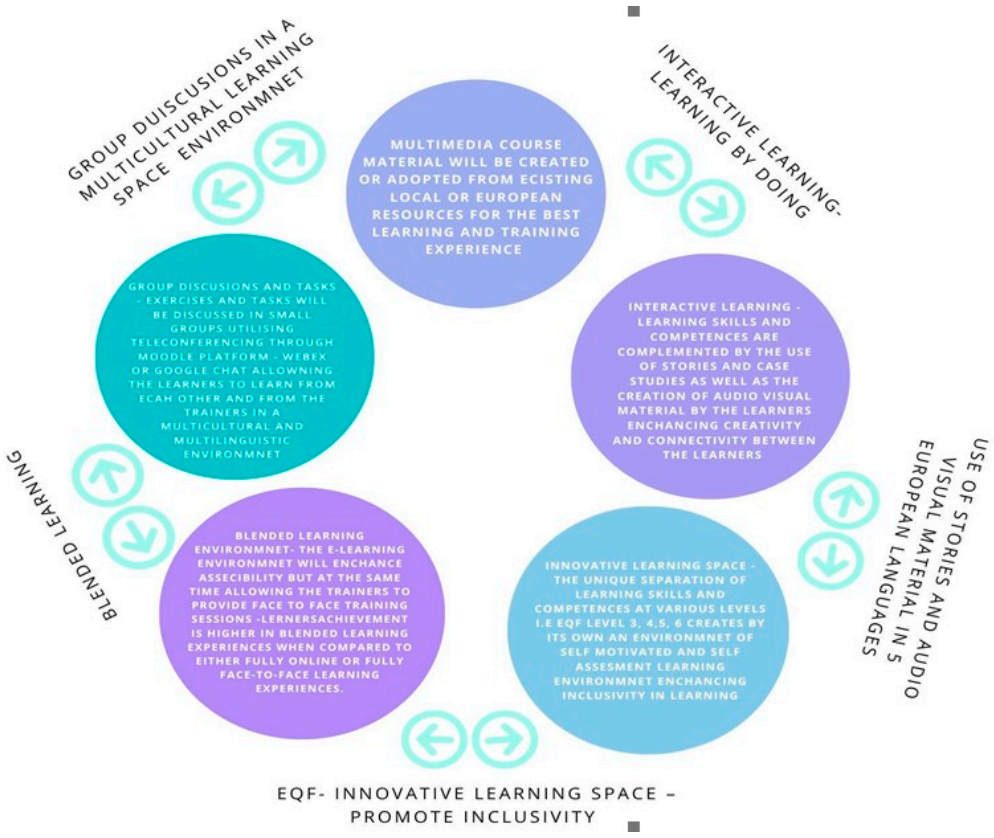

Figure 6. Digicult model for hybrid education.

Moreover, the competencies revealed by the analysis of questionnaires and interviews emphasise the need for enhancing foreign languages, written and oral communication, creativity/imagination, critical thinking, problem solving and the ability to work as part of a team. The diversity of the audience revealed the need for an innovative curriculum that takes into consideration individual learning needs as well as creating an environment of inclusivity. The model focuses on enhancing skills and competencies in a digital era by utilising cultural heritage. Learners develop information, intellectual abilities and a broader variety of competences on themes such as cultural heritage preservation and societal well-being by personally experiencing or analysing cultural assets. This kind of knowledge leads to sustainable economic growth actions, including opportunities for employment. Also, the research revealed that an e-learning pathway does not necessarily need to be 100% digitally delivered, as young learners' digital skills vary from country to country. The option of designing a blended mode of delivery may be more appropriate since it is likely to lead to better learning results.

As presented in the model, several learning strategies are utilised, such as story-telling, multicultural work, reflective tasks, teamwork and continuous assessment. Also, all these strategies can be utilised both face-to-face and online. In addition, they can be applied to individual tasks (self-assessments) and/or tasks involving teamwork (collaborative tasks). Nevertheless, it is important to underline that engagement and interaction among students are fundamental. Also, these strategies can be applied for both summative and formative assessments.

Moreover, "learning by doing" is applied as a means of facilitating the active involvement of learners in the learning process [16]. In other words, the model provides the opportunity to learn through concrete experiences and the application of what has been learned in a real-life situation—either individually or as part of a team. The ongoing process of the assimilation of experience into knowledge, known as Kolb's learning cycle, involves an interaction between action, reflection, experience and abstraction [64]. The four stages of Kolb's learning cycle are concrete experience, namely reflective observation, abstract conceptualisation, active experimentation and the foundations of experiential learning. In general, concrete experience is a time when learners engage in an experience in order to learn. Learners review their experiences through reflective observation. Departing from Kolb's learning cycle to the Experiential Learning Theory, the paper proposes a hybrid innovative model while adopting a pedagogical approach to implementing experiential learning in a digital learning environment for the education and training of young learners as part of SE.

Kolb's learning cycle can be utilised for reflexivity while attempting to apply the Digicult Model as a novel framework for learning. Many of the strategies presented in the Digicult Model (Figure 1) exist within the framework of reflexive learning. Through scholar–learner and learner–learner in-class collaboration (virtual or physical), reflexive learning provides space for the re-invention [65] of cultural heritage and the development of cultural identity. Reflecting on experiences has a central role in learning. The suggested model provides a context that fuels and is fuelled by the curiosity to search for, revitalise and merge traditional components of cultural heritage with contemporary, socially constructed learning. By reviewing and reflecting on cultural experiences, the Digicult model suggests a change in abstract knowledge to practice, cultivating a more systematic integration of cultural heritage in education.

However, reflexive learning can also be used at higher levels of decision making as a mode of inquiry and repositioning. Stemming from the interviews, our findings suggest an inconsistency in how cultural heritage is defined among different education systems. From one country and language to another, the terms "culture", "cultural heritage" and "education" are not defined in the same way. Thus, at a higher level, reflecting on current experiences and practices can facilitate a dialogue between stakeholders about what cultural heritage is and how it is utilised in a local context. According to Gorli et al, [66] reflexive learning can be used as a basis for action, questioning the status quo and seeking

change. Likewise, through cross-boundary collaboration, reflexivity can facilitate a better understanding of how other EU countries and regions understand cultural heritage and how it is currently utilised in education. Eventually, reflexive practice may result in a re-configuration of "cultural heritage" and its use in education. In this sense, reflexivity does not only facilitate performance and creativity, but it also acts as a transformative power that is likely to enable new possibilities, new understandings and clarity on courses of action through co-creation and inter-organisational collaboration [65].

As discussed in the Introduction, the term "digital native" implies that young people intuitively understand how to utilise technology, and therefore, they do not require digital education or training. All EU digital plans during the last decade, including the Digital Agenda for Europe [28], the Digital Single Market for Europe [29], and a Europe fit for the digital age [30], have attempted to make every European a digital native. However, research on young people's usage of the Internet and technology in Council of Europe member countries is limited. Eurostat data provide some insight into the situation in the European Union. In 2021, 95% of Europeans aged 16 to 29 reported using the Internet every day. The proportion of young people with basic or above-basic digital skills spans from 46% to 93%, compared to the EU average of 71%. In addition, 76% of all young people said they had carried out basic computer tasks like copying or moving a file or folder. At the same time, previous studies suggest that some young people are not as savvy (or unsavvy) with digital technology as we might think [67]. While they might not be technophobes, they still may not have certain literacy skills when it comes to digital devices, or they may be digitally deprived [68]. According to Eurostat [27], digital resources can offer valuable learning opportunities and life-changing experiences for students in a range of academic fields, especially those in subjects like hospitality and tourism.

4.2. Implication to Practice

While the practices discussed earlier are part of SE, what is of great importance in this model concerns learning opportunities based on substantial historical and/or cultural backgrounds, allowing students to become more deeply involved in their studies or even to recognise themselves for the first time as unique cultural scholars. This is because the model utilises digital cultural heritage while focusing on skills and competencies such as critical thinking, creativity and innovation through the learning of cultural heritage (tangible and intangible). This is the reason we argued that SE can never be fully sustainable unless it integrates cultural heritage experiences into the learning process. Also, according to the e-learning education paradigm, new digital tools and content are required to engage young learners to develop critical core competencies that will increase their employability and productivity. Learning does not have to be online. It can be blended learning, given that teaching in brick-and-mortar environments can still incorporate computer-based tasks and interaction. The implications for education are considerable since the use of a model that places more emphasis on interactive outputs than on content can support the design of interactive labs (physical or online) that cover both the acquisition of new digital skills and the development of knowledge and abilities that will unite young people in Europe through a digital cultural environment. This is the essence of SE, which brings together learning strategies and pedagogies for resilience, inclusiveness and progress.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16041540/s1, Questionnaire S1.

Author Contributions: Conceptualization, Y.O. methodology, G.P. collection of findings, L.E., analysis of findings, L.E. and Y.O.; G.P., concluding discussion, L.E., review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and since the study was undertaken as part of an EU-funded project, research ethics approval was granted by the project consortium's legal office.

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

Data Availability Statement: Data will be destroyed after publication in line with International Research Ethics' standards and as outlined in the Informed Consent Form.

Acknowledgments: This paper was supported by research conducted under the project titled DIGICULT under the 2021-1-IT01-KA220-VOCATIONAL-000034836 Erasmus+ KA220-Cooperation partnerships in education and training.

Conflicts of Interest: The authors declare no conflicts of interest.

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ISBN 978-3-7258-2331-4