electronics

Article

The Influence of E-Scaffolding Sources in a Mobile Learning Environment on Students' Design Skills and the Technology Fatigue Associated with a 3D Virtual Environment

Ensaf Nasser Al Mulhim [1,*] and Yara Ahmed Mohebeldin Zaky [2]

[1] Department of Curriculum and Instruction, Faculty of Education, King Faisal University, Al-Ahsa 31982, Saudi Arabia
[2] Faculty of Specific Education, Ain Shams University, Cairo 11566, Egypt; dr.yara.a.moheb@sedu.asu.edu.eg
* Correspondence: ealmulhim@kfu.edu.sa

Abstract: This article examines the influence of teacher/peer e-scaffolding in a mobile learning environment on students' design skills and the technology fatigue associated with a 3D virtual learning environment. The sample consisted of 32 postgraduate students who were divided into two groups according to their e-scaffolding source (teacher/peer). The findings showed that peer e-scaffolding outperformed teacher e-scaffolding in the mobile learning environment in terms of students' development of design skills. The findings also showed that students became moderately fatigued after designing the 3D virtual environments in both experimental groups. This study can act as a guide for teachers and instructional designers by helping them to select the most suitable e-scaffolding source when teaching 3D virtual environment design skills. This may result in better and easier skill development.

Keywords: teacher e-scaffolding; peer e-scaffolding; mobile learning environments; 3D virtual learning environment; designing skills; technology fatigue

Citation: Al Mulhim, E.N.; Zaky, Y.A.M. The Influence of E-Scaffolding Sources in a Mobile Learning Environment on Students' Design Skills and the Technology Fatigue Associated with a 3D Virtual Environment. *Electronics* **2022**, *11*, 2172. https://doi.org/10.3390/electronics11142172

Academic Editor: Christos J. Bouras

Received: 11 June 2022
Accepted: 5 July 2022
Published: 11 July 2022

1. Introduction

Educational institutions around the world were forced to suspend traditional classroom activities as part of the preventive actions taken to limit the spread of COVID-19. This has led to an increased interest in using e-learning, and the use of computers, mobile devices, and technology in general has become crucial across the curricula. Furthermore, modern technologies that enable learners to simulate and interact with reality have become necessary. Three-dimensional (3D) virtual environments are a good choice for this purpose. The use of the third dimension increases the sense of realism, giving the ability to produce life situations that attract learners to interact and engage more with learning materials and peers [1]. It is also possible to use 3D virtual environments anytime and anywhere so that learners can communicate through virtual characters to share information and experiences together [2]. Virtual 3D environments help learners to live in any environment, no matter how realistic or imaginary. Such environments also help learners to simulate reality, through which they can navigate to be immersed in live events, where they can behave similarly to how they would in the real world, with the advantage of avoiding expected dangers [3].

With the spread of mobile devices, the interest in using them in education through smartphones and tablets has increased [4]. Their use is no longer limited to exchanging messages or playing games. Many new applications have appeared in various fields, including educational applications that can be employed in classrooms to help teachers and learners communicate rapidly, improve the processes of interaction, deliver content in an attractive and interactive way, and share various types of information (texts, images, videos, etc.) easily [5].

Furthermore, distance education can be asynchronous, so learning is self-paced, which provides the learner with the flexibility to learn and interact at any time and in any place. As learners are on their own while learning distantly, they need support, guidance, and assistance, so e-scaffolding may be provided to them through the mobile learning environment.

The greater dependence on technology during the COVID-19 pandemic resulted in more reports of technology fatigue [6–9]—a concept that can result from being required to stay in front of technology screens using platforms and video programs for long periods of time [10]. It is becoming increasingly clear that physical and psychological stress from technology fatigue can affect people's work and personal lives, making them less motivated, productive, and attentive. Therefore, the issue of the interaction between humans and computers, and its consequences, should be highlighted. However, only a few papers can be found regarding technology fatigue research in the Saudi education system.

E-scaffolding is a way to provide temporary support and direction to learners during the learning process to help them to complete new learning tasks and to encourage them to build knowledge by themselves. This is something that learners may not be able to do without this help [11]. E-scaffolding may take the form of instructions, tips, and/or messages of help. It may involve asking questions and presenting additional examples related to an educational situation to ensure the continuity of the educational process, and to guide the learners towards mastering various areas of knowledge, ability, and skills to achieve their educational goals successfully [12].

The different sources of e-scaffolding (teachers/peers) in the mobile learning environment play a role in increasing the effectiveness of educational situations. The related body of literature shows that both teacher e-scaffolding and peer e-scaffolding have the power to help students to achieve their learning goals [5,13–23]. Most of the studies found on the scaffolding sources were in other fields than educational technology, such as learning English [14–16,19,20,22,24–30]. Similarly, only a few papers comparing scaffolding between teachers and peers can be found. Therefore, little is known about the most appropriate sources of e-scaffolding for students that can help them to master the skills involved in designing 3D virtual reality learning environments, and which may reduce the technology fatigue that they may experience.

Where the present study aims at developing the skills of those designing 3D virtual learning environments, mastering these skills is assumed to consume a lot of time and effort in the use of technology. Scaffolding through a mobile learning environment has been used to support learners in mastering the skills of designing these virtual environments, attempting to reduce the technology fatigue that might be experienced by the students. For this reason, the authors believe that such a study should be conducted to find out how e-scaffolding may reduce the fatigue resulting from the design of the virtual environments.

This study's main aim was to investigate the effects of e-scaffolding from different sources (teachers/peers) in a mobile learning environment on students' design skills, as well as on the technology fatigue resulting from immersion in designing a 3D virtual learning environment.

2. Literature Review

2.1. E-Scaffolding

Scaffolding is a Vygotskyan concept that focuses on providing supportive aid from adults or experts to learners within the learning zone of proximal development. According to Dabbagh [31], the zone of proximal development refers to the difference between the current knowledge and ability of learners and what they can accomplish with or without assistance when tackling a challenge. Scaffolding helps learners by gradually limiting complexities present in the learning context, and then removing those limits as the learners gain knowledge, confidence, and skills in tackling complex concepts. In scaffolding, assistance is provided to learners when needed. However, as task competency increases, assistance fades gradually, allowing low-level learners to complete tasks independently.

There are three types of scaffolding: hard, teacher, and peer scaffolding. Hard scaffolding is static support that can be planned with learners who face potential difficulties in a given context [32]. Inquiry-based learning students widely use hard scaffolding. For example, hard scaffolding includes professional videos that offer problem-solving support through clues and samples in the form of text or video to aid in understanding. Although hard scaffolding has a positive impact on the learning environment, it has various deficiencies. The method excludes learners from interacting with more advanced learners and teachers. As a result, students who use hard scaffolding without interacting can inadequately internalize information presented to them. Peer scaffolding is the process in which learners offer problem-solving solutions to their peers when needed [33]. Peer scaffolding encourages group collaborative learning, and enhances face-to-face interactions during discussions [34]. In addition, peer scaffolding promotes a high level of cognitive thinking, since the method encourages the use of extra clues and immediate feedback [33]. According to Amerian et al. [26], the use of sociocultural theory in peer scaffolding provides opportunities for students to develop their language skills. Teacher scaffolding is also known as institutional scaffolding, and it involves support from teachers throughout the learning process to enhance mastery of tasks [29]. Teachers use various strategies to achieve scaffolding functions in the zone of proximal development [16]. For instance, teachers provide resources, questions, prompts, and expert advice to learners, as well as learning tools and guides [35]. In addition, teachers ensure self-regulated learning through teacher scaffolding, dialogue, and graduated (considering academic level) education [28].

According to Ebadi and Beigzadeh [14], peer and teacher scaffolding are effective techniques for helping students to improve their reading comprehension abilities. However, comprehension development research has shown that teacher scaffolding mediates learners' comprehension skills more effectively than peer scaffolding [36]. Teacher scaffolding enables students to become independent and self-regulated learners when solving problems [37]. In addition, teacher scaffolding helps to facilitate the ability of learners to build prior knowledge and internalize new information [27]. Riazi and Rezaii [29] conducted a study in which they examined the effect of scaffolding on EFL students' writing ability. The study compared teacher and peer scaffolding in terms of their ability to help students improve their English. The findings revealed that the EFL students in the teacher scaffolding group performed better in writing. Sun et al. [23] investigated the use of teacher scaffolding in digital game-based learning in primary mathematics classrooms, as well as its effects on students' perceptions of learning in a digital game environment. For this purpose, the authors conducted a study involving 141 primary school students and 4 mathematics teachers, and collected qualitative data through classroom observations and student interviews. The results showed that both whole-class and one-to-one scaffolding strategies are important for students' learning activities and perceptions when learning mathematics in a digital games context in primary education. Kuhoof [38] studied the effects of interaction between the support source (teachers/peers) and the participating group size (medium/large) in an e-learning environment on attitude development and the quality of e-tests created for students at the faculty of Science and Arts in Sharurah, Saudi Arabia. The results revealed that the group who received teacher scaffolding developed better attitudes towards the e-learning environment and produced better e-test results, regardless of the size of the participating group (medium/large). Another study by AlThiyabi and Al-Bargi [25] examined the effect of teacher scaffolding on the level of classroom interaction in a learning English as a foreign language course at King Abdulaziz University, Saudi Arabia. The analysis of qualitative data obtained from video recordings of 10 male EFL classes indicated that teacher scaffolding exerted a positive impact on the level of classroom interaction.

A significant body of literature recommends the use of peer scaffolding to improve students' learning. For instance, a study conducted by Ozlem [39] used three sources of scaffolding—teachers, peers, and learning technology materials—to deliver course content in a networked learning environment. The findings of the study showed that peer scaffolding was the best source of the three. A study by Shehadeh [30] found that peer scaffolding enhanced students' writing competence, speaking ability, and self-confidence. A comparative study by Jamali Kivi et al. [15] that examined the effects of teacher versus peer scaffolding on EFL learners' incidental vocabulary learning and reading comprehension reported that learners' reading comprehension scores were better in the peer-scaffolding group. Another study by Abune [24] examined the effect of peer scaffolding on grammar proficiency development in 101 students. The experimental group was involved in a peer-scaffolding-based learning experience aimed at improving grammar proficiency for two months. The control group participated in the same grammar proficiency activities, but had teacher instruction only. The findings from the pre- and post-tests illustrated that the experimental group showed greater improvement in grammar proficiency than the control group. Kim et al. [17] suggested the use of a peer scaffolding system to enhance K–12 students' autonomy and competence by providing scaffolding in accordance with students' different needs and difficulties in problem-based learning environments. The study concluded that peer scaffolding between students with similar abilities satisfied students' needs for autonomy, competence, and relatedness. Saleh et al. [21] conducted a case study where students provided scaffolding to facilitate collaborative game-based learning centered on an ecological problem. The results suggested that the students collaborated productively—both face-to-face and digitally (through in-game chat)—to solve the ill-defined problem in the game-based learning environment.

Mansouri and Heidar [19] conducted a study aimed at exploring the effects of peer and teacher scaffolding in a technology-enhanced environment on vocabulary learning among a total of 120 high- and low-self-regulated learners. The participants were divided into three groups, namely, peer scaffolding, teacher scaffolding, and control groups, each consisting of 40 learners. The teacher scaffolding was delivered via the Telegram application. The results revealed that both peer and teacher scaffolding have significant effects on vocabulary learning, but no significant difference between peer and teacher scaffolding was identified in terms of their effects on vocabulary learning. Sabet et al. [20] examined the influence of peer scaffolding through a process approach on the writing fluency of 40 EFL learners. The results did not show any impact of peer scaffolding on the experimental group. This result is consistent with findings from a study by Karimi and Jalilvand [16]. The authors conducted an experiment to compare the effects of the source of scaffolding on the reading comprehension of EFL learners. The experiment consisted of two experimental groups and one control group. The first experimental group received both teacher and peer scaffolding, whereas the second group received only peer scaffolding. The findings illustrated that the use of teacher scaffolding accompanied by peer scaffolding can have more positive effects on the reading comprehension of EFL learners. This result is consistent with that of a study conducted by El-Tabakh and El-Moher [40] on the effects of different support sources (teacher/peers) in the cloud learning environment on the development of skills related to the design of Web 2.0 applications for students from the Faculty of Specific Education in Egypt. They reported that teacher e-scaffolding may be more appropriate when the cognitive aspect of skills is considered, whereas peer e-scaffolding is preferable when practical skills are involved.

In sum, previous studies have presented different views on which source of scaffolding may have a better effect on students' learning outcomes. Each opinion is supported by a number of studies, as shown above. Thus, the literature has not yet confirmed the best source of scaffolding for students. In addition, little is known about which source of e-scaffolding is most appropriate for a mobile learning environment to support students' design skills and reduce technology fatigue from immersion in a 3D virtual learning environment. These concepts are covered in the present study.

2.2. Three-Dimensional Virtual Learning Environments

Three-dimensional (3D) virtual environments create interactive environments by employing the feature of the third dimension. The main goal of 3D virtual learning environments is to motivate and stimulate learners [41]. Such learning environments provide students with opportunities to experience practical learning without the risks that may be involved in traditional instructional environments [42]. Learners have the ability to experience real environments and be actively involved with the components of the virtual environment, thereby increasing their immersion, interaction, and sense of realism [43]. Three-dimensional virtual environments are an effective way to create interactive environments in which abstract concepts and skills can be developed through problem solving, exploration, and experimentation [44–46].

Tilhou et al. [47] defined 3D virtual environments as 3D interactive spaces that can be used for various purposes. They mostly involve the use of games to simulate real-world environments for entertainment purposes. According to López et al. [46], 3D virtual environments are computer-generated environments that users can interact with using a variety of tools, such as virtual reality headsets, smartphones, or computers. There are three main virtual environment types: non-immersive, semi-immersive, and fully immersive simulations. The most immersive virtual environments are created using 3D graphics [48].

This environment has been applied extensively in the education field, and there has been remarkable growth in the application of these environments for distance learning [45]. These environments are reportedly useful for sharing activities and cooperation among learners [49]. Furthermore, a study conducted by Glaser and Schmidt [50] reported that the use of a customizable 3D virtual environment enhanced the development of knowledge and skills and met the unique needs of individuals with autism. Another study was conducted by Cantey et al. [51] on the use of a virtual learning environment by nursing students during the COVID-19 pandemic, whereby clinical skills were simulated in a virtual laboratory environment. The results indicated that the students found that the virtual environment was engaging and helpful. They stated that nursing skills were taught successfully in a virtual learning environment.

On the other hand, 3D virtual environments have some challenges. The related body of literature details some of the limitations of virtual environments, including health issues such as cyber sickness [52], nausea, motion sickness, and headaches while using the devices [42,53]. Another drawback is technical issues and Internet outages [54,55]. Users also might miss realistic visual–haptic interactions [52]. Boyles [54] stated that the application of virtual environments requires teachers and students to spend additional time learning how to use virtual reality devices. Schroeder [56] added that the process of producing and using virtual environments can be time-consuming and resource-intensive. There may also be an additional cognitive load caused by navigating and exploring in the virtual world [55]. Teachers need to procure or design virtual environments or hire specialists, taking into account the fact that these environments need to be customizable so that teachers can adjust them to fit their teaching and students' learning needs [54]. Virtual reality is not always the best method for achieving learning goals [57], so teachers need to be careful when selecting this technology. There is also concern about the isolated social user experience, especially when using the fully immersive environments [52].

To summarize, the employment of virtual environments in education involves many benefits and drawbacks. Thus, these environments require more attention from designers as well as teachers when designing and utilizing them to ensure that their benefits are taken advantage of and their disadvantages are avoided. The present study worked on the development of postgraduate students' skills through the design of 3D virtual learning environments, and measured the levels of technology fatigue involved in the design of such environments.

2.3. Technology Fatigue

Technology fatigue is associated with the introduction of numerous new technologies that individuals need to become familiar with and use within a limited period of time, causing them to feel unable to keep up to date with all of the new technologies [58]. It is also associated with being required to stay in front of technology screens using platforms and video programs for long periods of time [10]. Recently, as a result of the COVID-19 pandemic, technology has become a vital part of people's daily lives, and is used for work and learning [10,59,60]. However, this massive dependence on technology has resulted in greater incidence of technology stress, overload, and fatigue [61,62]. A significant body of literature has reported technological consequences such as lower productivity [63] and academic achievement [64]. Technology fatigue also has negative effects due to physical and psychological strain [44,65], such as headaches, stiff shoulders, eyestrain, backaches, difficulty sleeping, and depression [66].

Al Mulhim [67] conducted a study on the levels of technology fatigue experienced by undergraduate students studying in a distance-project-based learning environment in Saudi Arabia during the COVID-19 pandemic. The participants were found to be moderately fatigued in the mentioned environment. The author believes that this was because the participants were final-year students from the Educational Technology Department and, thus, were familiar with exposure to technology for long periods of time, as well as project-based learning. Halupa and Bolliger [68] explored the levels of technology fatigue experienced by students in a higher education faculty in the United States, as well as their perceptions of technology fatigue. The study's results confirmed that all participants experienced moderate technology fatigue. Both of these studies—Al Mulhim [67] and Halupa and Bolliger [68]—analyzed the factors mitigating technology fatigue. Both reported that receiving support is crucial to lessening technology fatigue.

The concept of technology fatigue may fit with the transactional theory of stress and coping developed by Lazarus and Folkman [69]. According to this theory, stress is a transactional process in which stressors interact with an individual's ability to keep working in order to achieve their goal. As a response to these stressors, an individual may feel fatigued [70]. The different types of stressors available in the environment include demands, conditions, workload, novelty, ambiguity, and uncertainty about a situation [65,69].

Working with technology for long periods of time may be an important stressor. It may create an extra workload for individuals, especially when they have to use technology extensively, for longer, or at a faster pace than they can manage. This has been reported to be exhausting [71,72]. In this paper, the transactional theory of stress and coping is used to discuss the results of the participants' technology fatigue levels when designing 3D virtual environments.

During the COVID-19 pandemic, students were required to use technology instantly and for unknown periods of time. This extensive application of technology has resulted in many reports of technology fatigue [6–10]. In addition, mastering 3D virtual environment design skills is time- and effort-consuming, requiring students to be on their devices extensively. As mentioned above, 3D virtual environments may cause cyber sickness, nausea, motion sickness, and headaches [16,52,53]. This can be exhausting. Few studies have focused on technology fatigue during the COVID-19 pandemic in postgraduate students—either in general or in terms of the design of 3D virtual environments. This study aims to bridge that gap.

3. Questions

Q1: What is the influence of the e-scaffolding source (teacher/peer) used in a mobile learning environment on the development of students' 3D virtual environment design skills?

Q2: What is the influence of the e-scaffolding source (teacher/peer) in a mobile learning environment on the level of technology fatigue experienced by students?

4. Hypotheses

Hypothesis 1 (H1). *There will be no statistically significant differences ($p \leq 0.05$) in the average scores of two experimental groups on a design skills assessment conducted in a 3D virtual environment due to the e-scaffolding source used (teacher/peer).*

Hypothesis 2 (H2). *There will be no statistically significant differences ($p \leq 0.05$) in the average scores of two experimental groups in terms of technology fatigue experienced when designing a 3D virtual environment due to the e-scaffolding source used (teacher/peer).*

5. Participants

This study purposively recruited all 32 postgraduate students enrolled in the Master of Educational Technology program at King Faisal University, Saudi Arabia. The students were enrolled on a course called "Technology Applications in Education" during the second semester of the 2021/2022 school year. They were divided into two groups of 16 students each.

6. Methodology

This study utilized the experimental research approach to explore the influence of the e-scaffolding source (teacher/peer) used in a mobile learning environment on the development of students' design skills in a 3D virtual environment, and the levels of technology fatigue experienced.

7. Research Design

When setting up the experimental intervention for the study, the ADDIE model for instructional design proposed by Branch [73] was considered:

1. Analysis Stage
    - 1.1 Determining the general objective of learning: The general goal of learning in this study was to identify the influence of the e-scaffolding source (teacher/peer) used on the development of design skills in a 3D virtual environment, and on the levels of technology fatigue experienced by postgraduate students at the Faculty of Education, King Faisal University.
    - 1.2 Determining learners' characteristics: The characteristics of the participants were analyzed. The participants were postgraduate students from the Master of Educational Technology program at King Faisal University, Saudi Arabia. They were enrolled on a course called "Technology Applications in Education". They had basic computer skills, and were able to use smartphone applications and tools. They were unfamiliar with the educational content associated with designing a 3D virtual environment.
        - Assessing learning needs: To enhance the skills associated with designing a 3D virtual environment.
        - Assessing skills analysis: 3D virtual environment design comprises four main skills, each including a number of subskills. These were presented to experts in the field of educational technology for assessment. The suggested modifications were implemented, and the final list of the skills was as follows:
            - ✔ Selecting a learning topic of the student's choice to apply to the 3D virtual environment (6 skills);
            - ✔ Creating the 3D virtual items using the learning environment (5 skills);
            - ✔ Applying movement and navigation skills in the 3D virtual environment (17 skills);
            - ✔ Adding the proper codes for each command (3 skills).
    - 1.3 Analysis of the technological environment: The technological environment requires the following:
        - ✔ Smartphones or tablets with Internet access;
        - ✔ The WhatsApp application as a group tool for facilitating communication, interaction, and file sharing among students in both experimental groups;

- ✔ The Blackboard learning management system to deliver an introductory meeting with the experimental groups through the virtual classroom tool;
- ✔ The CoSpaces website and mobile application to design the 3D virtual environment;
- ✔ The YouTube website and mobile application to watch and share instructional videos on how to design the 3D virtual environment using the CoSpaces application.

2. Design Stage

    2.1. Setting educational objectives: Four main behavioral objectives associated with 3D virtual environment design skills were identified:

    - ✔ Selecting a learning topic of the student's choice to apply to the 3D virtual environment;
    - ✔ Creating virtual 3D items with the learning environment;
    - ✔ Applying movement and navigation skills in the 3D virtual environment;
    - ✔ Adding the proper code for each command.

Then, a list of 31 behavioral learning objectives (Table 1) was presented to a group of five educational technology experts to assess the validity and formulation of the objectives. Some amendments to the wording of the objectives were suggested. After making these amendments, the final version of the behavioral learning objectives was ready to use.

Table 1. The 3D virtual environment design skills assessment card.

No	Skills	Poor	Fair	Good
		0	**1**	**2**
Selecting a learning topic of the student choice				
1	Choosing a topic suitable for the virtual environment			
2	Setting a learning goal			
3	Dividing the Content			
4	Present the content from simple to complex			
5	The content is valid			
6	There are no grammatical errors			
Using co spaces Edu platform to design the elements of 3D virtual environment				
1	Creating an account on the co spaces Edu platform			
2	Creating a new classroom on the platform			
3	Choose two or more scenes from the co spaces Edu platform library			
4	Adding virtual characters to the environment			
5	Using co spaces Edu platform library to choose virtual elements			
Applying movement & navigation skills in3D virtual environment				
1	Setting the orientation of the virtual characters and items			
2	Adding characters' materials and default items			
3	Changing the color of characters and items			
4	Controlling the size of characters and virtual items			
5	Controlling the angle of the virtual characters and items			
6	Choosing the appropriate emotions for the virtual character			
7	Choosing the appropriate motion of the elements to fit with the design of the environment			
8	Adjust the proper size of elements within the virtual environment			
9	Inserting multimedia elements such as (image, video, audio, . . .)			
10	Including appropriate sound effects			
11	Using a voice appropriate for the virtual character			
12	Using the appropriate font for the text			
13	Using appropriate color for text			
14	Including a feedback question appropriate to the content			
15	Adjusting the place of camera movement into scene			
16	Moving the virtual camera forward, backward, left and right			
17	Creating a path for camera movement			
Adding the proper codes for each command				
1	Creating a code for the virtual characters and items			
2	Controlling the movement of two characters moving at the same time			
3	Adding a code to adjust the movement of the camera			
	Total			

2.2. Designing the e-scaffolding sources in a mobile learning environment: The study applied two e-scaffolding sources (teacher/peers). Both groups were assigned the same tasks and required to master some design skills. The teacher sent the tasks to both experimental groups via WhatsApp groups. The students used the WhatsApp groups to communicate, interact, and discuss ideas with the teacher or peers, depending on the e-scaffolding source.

- ✔ Designing the teacher e-scaffolding source: The teacher sent instructions and resources (e.g., video clips, text files, pictures, and links) to the students.
- ✔ Designing the peer e-scaffolding source: There were no instructions or resources provided to the students from the teacher. Students were encouraged to socially interact with and help one another to accomplish their tasks.

3. Development Stage

For this stage, two WhatsApp groups were created—one group for each e-scaffolding source (teachers/peers). The WhatsApp groups acted as platforms to deliver assignments for both experimental groups. They were also a means to suggest learning resources and contact the teacher (for the teacher e-scaffolding source), and to induce social discussion and interactions among students (for the peer e-scaffolding source).

4. Implementation Stage

A pilot study was conducted on a sample of 10 purposively selected students from the College of Education who were not involved in the main experiment, and who had the same characteristics as the main experiment sample (postgraduate students enrolled in the Master of Educational Technology program and registered on a course called "Technology Applications in Education" during the second semester of the 2021/2022 school year.). They were divided into two groups of five students. Each group was treated with one of the study's two e-scaffolding sources (teachers/peers). The pilot study took place between 27th February and 19th March.

This pilot study was conducted to ensure that the e-scaffolding sources (teacher/peer) used suited the students, and to determine the validity and reliability of the study's instruments. It was also conducted to identify any difficulties that might occur while implementing the main experiment.

5. Evaluation Stage

This stage involved the formative evaluation of all previous stages in order to ensure the validity of all previous stages, taking into account the results of the pilot experiment.

All modifications needed were applied, and the interventions were made ready for implementation in the study's main experiment.

8. Data Collection Instruments

8.1. Technology Fatigue Survey

The technology fatigue survey was adapted from Al Mulhim's [67] study of technology fatigue in distant-project-based learning environments. The survey consists of 20 closed-ended items, including four reversed items. The survey uses a four-point Likert scale (strongly agree = 4; agree = 3; disagree = 2; strongly disagree = 1).

The survey scores ranged from 20 to 80. A total of five experts from the educational technology field evaluated the instrument's validity. The experts recommended rephrasing some of the items for more clarification. The recommended modifications were carried out, and the instrument then reached its final form.

The internal consistency of the survey was calculated by Cronbach's alpha coefficient, which was found to be as high as 0.904. This indicates that the number of the survey's items was enough, and that they were closely related. The reliability of Al Mulhim's [67] original technology fatigue survey was 0.92. The current study's survey reliability was calculated using the split-half method from the pilot sample. The Spearman's coefficient was 0.903, indicating a high and significant level of reliability.

8.2. Skills Assessment Card

To evaluate the 3D virtual environment design skills of the students, a skills assessment card was created. The skills in the card were adapted from the CoSpaces Edu main skill list. The final assessment card consisted of 31 items to be evaluated on a three-point Likert scale (poor = 0; fair = 1; good = 2). The card scores ranged from 0 to 62 points. The 3D virtual environment design skills card is shown in Table 1.

The validity of the skills assessment card was judged by a group of five experts in the field of educational technology. They recommended the addition of some items to the card. There was good consensus on the card's validity in general. The reliability of the skills assessment card was calculated from the data gathered from the pilot experiment using test–retest method. The Pearson's coefficient was 0.88, indicating a highly significant reliability of the card.

9. Experimental Procedure and Data Collection

The 32 postgraduate students were randomly divided into two groups of 16 students. The first group used the teacher e-scaffolding source, and the other group used the peer e-scaffolding source. An introductory meeting was held with both groups to explain both interventions. The participants were made aware of the 3D virtual learning environment design skills that they needed to develop to successfully complete the projects. A skills pre-assessment was applied to ensure homogeneity between the two groups. A group was set up on the WhatsApp application with the teacher for each group. In the teacher e-scaffolding source group, the students were instructed not to help their peers at all. All questions were supposed to be answered by the teacher. On the other hand, in the peer e-scaffolding source group, the students were strongly encouraged to help one another, and the teacher did not take part in the students' discussions. Figures 1 and 2 show examples of virtual environments created by the participants.

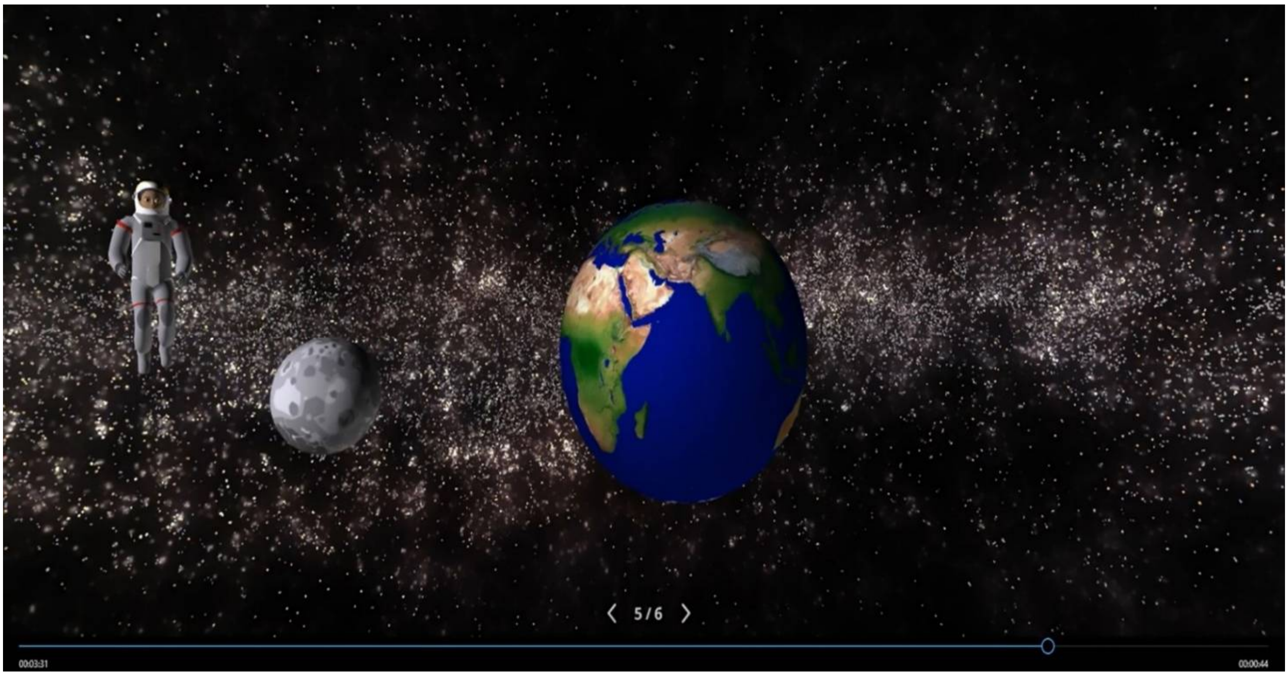

Figure 1. Example # 1 of students' virtual environments (outer space).

Figure 2. Example # 2 of students' virtual environments (deep ocean).

The application of the research experiment took about three weeks (3–24 April 2022). The skills assessment card and the technology fatigue survey were carried out once the experiment had been completed. Then, the scores from the data collection tools were prepared for statistical analysis. Using SPSS, data were processed and statistically analyzed using the independent-samples *t*-test to find the significance of differences between the experimental groups.

10. Data Analysis and Results

A sample normality test was carried out to ensure that the sample was normally distributed (Table 2).

Table 2. Normality test of the experimental groups.

Group	N	Skewness		Kurtosis		Shapiro–Wilk		
		Statistic	Std. Error	Statistic	Std. Error	Statistic	df	Sig.
Peer e-scaffolding group	10	−0.273	0.564	−0.861	1.091	0.927	16	0.217
Teacher e-scaffolding group	10	−0.248	0.564	−1.399	1.091	0.899	16	0.076

Based on the results shown in Table 2, the skills assessment card scores of both experimental groups were approximately normally distributed, where the Shapiro–Wilk test was not significant ($p > 0.05$) [74]. The peer e-scaffolding group had a skewness of −0.273 (SE = 0.564) and a kurtosis of −0.861 (SE = 1.091), while the teacher e-scaffolding group had a skewness of −0.248 (SE = 0.564) and a kurtosis of −1.399 (SE = 1.091) [75].

A skills pre-assessment was used before applying the experimental intervention to ensure homogeneity between the experimental groups (Table 3).

As shown from Table 3, the independent *t*-test revealed that there were no statistically significant differences between the two experimental groups before applying the experiment ($t = 0.367$, $p > 0.05$); thus, they were considered to be homogeneous.

Table 3. Independent-samples *t*-test of the skills pre-assessment.

Group	N	Mean	S.D.	df	*t*	Sig.
Peer e-scaffolding group	16	3.44	2.581	30	0.367	0.456
Teacher e-scaffolding group	16	3.13	2.217			

Another skills assessment (post-assessment) was conducted once the intervention had been completed. Table 4 illustrates the independent *t*-test of the post-intervention assessment of both experimental groups.

Table 4. Independent-samples *t*-test of the skills post-intervention assessment.

Group	N	Mean	S.D.	df	*t*	Sig.
Peer e-scaffolding group	16	54.38	2.754	30	6.086	0.009
Teacher e-scaffolding group	16	46.75	4.187			

The results of the *t*-test analysis found statistically significant differences ($p \leq 0.05$) between the average scores of the students from the two experimental groups on the skills card, in favor of the peer-scaffolding group ($t = 6.086$, $p < 0.05$), which had the highest mean value of (M = 54.38; S.D. = 2.754). Thus, the first hypothesis was rejected.

Another independent-samples *t*-test was also used to identify the significance of the differences in the technology fatigue survey between the two experimental groups. Table 5 shows these results.

Table 5. Independent-samples *t*-test of the results of the technology fatigue survey.

Group	N	Mean	S.D.	df	*t*	Sig.
Peer e-scaffolding group	16	43.81	8.780	30	1.065	0.813
Teacher e-scaffolding group	16	47.38	10.092			

As revealed from Table 5, there were no statistically significant differences ($p \leq 0.05$) between the average scores of students from the two experimental groups in the technology fatigue survey ($p > 0.05$). Therefore, the second null hypothesis was accepted. The overall average score was 2.2/4, indicating a moderate level of technology fatigue.

11. Discussion

The results of the test of the first hypothesis reflect an influence of the e-scaffolding source used in a mobile learning environment on the development of students' 3D virtual environment design skills, in favor of the peer e-scaffolding (Table 4). This result may be interpreted as peer e-scaffolding being better when teaching practical aspects of design skills, as mentioned by El-Tabakh and El-Moher [40]. Students like to be helped by their peers, so this may enhance the development of their skills and support effective participation and free engagement, with no restrictions from the teacher's instructions or directions. During the intervention, the students asked their peers about their 3D virtual environments and the codes needed for each component. Thus, they improved their own environments based on their peers' opinions, critiques, and advice. The students would have had different points of view, with all aiming to improve their 3D virtual environment design skills. Moreover, the participants in the peer e-scaffolding group were free to contact one another at any time during the day via the WhatsApp group. On the other hand, the participants in the teacher e-scaffolding group were not active enough in the WhatsApp group, and only asked the teacher about their tasks privately.

This result is also consistent with the Vygotskian social constructive theory that asserts that learning is an active social process, where learners cooperate with their more knowledgeable peers to get them out of their zones of proximal development (ZPDs). They help one another to accomplish different tasks and solve problems that they are unable to do on their own.

This result is consistent with the findings of many studies, such as those conducted by [17,21,24,30,39,40].

The second hypothesis tested the differences in the levels of technology fatigue experienced by postgraduate students receiving e-scaffolding from teachers versus peers in a mobile learning environment. The result showed no differences in the levels of technology fatigue experienced by the two experimental groups. This result may be attributed to the fact that participants in both experimental groups worked in the same type of learning environment—mobile—which offered them a significant amount of flexibility. They were able to share different types of files easily and interact with one another or with their teachers to get support at any time. They were able to design their 3D virtual environments either on the CoSpaces website using desktops or laptops, or on the application using mobile devices. Both groups had the same main task—designing a 3D virtual environment—and subtasks. They needed to master the same design skills in the same period of time. They needed to exert the same amount of effort to produce their virtual environments. They received support when required, although the source of that support (teachers/peers) differed.

Although exposure to technology over a long period of time is believed to be exhausting [10,51,58,61–66], the resultant technology fatigue experienced by participants of this study was only moderate. This result is inconsistent with the body of literature on 3D virtual environments, where it is reported that the use of such technology may result in health issues such as cyber sickness, nausea, motion sickness, and headaches [42,52,53]. Our results are also in contrast with the transactional theory of stress and coping developed by Lazarus and Folkman [69], which asserts that stress is the result of an individual's inability to keep working in order to achieve their goal due to the effects of the workload, novelty, ambiguity, or uncertainty of events. In this study, the task of designing a virtual environment was absolutely novel and ambiguous for the participants, as identified in the design skills pre-assessment (Table 3).

The finding of a moderate level of technology fatigue is consistent with that of Al Mulhim [67]. This level of fatigue may be because the participants were the designers of the environments but were not users of them, so they were not immersed in the virtual environments. Instead, they were using flat screens for design rather than using special virtual appliances. They also worked with some kind of scaffolding that simplified the work for them. This concept is consistent with the findings of studies by Al Mulhim [67] and Halupa and Bolliger [68], showing the significance of providing support to lower the level of technology fatigue.

12. Conclusions

This study explored the effects of e-scaffolding sources (teachers/peers) in a mobile learning environment on developing students' design skills, and on the technological fatigue levels associated with a 3D virtual environment during the COVID-19 pandemic. The study emphasized the excellence of using peer e-scaffolding instead of teacher e-scaffolding in a mobile learning environment when designing 3D virtual environments. The results also showed that the participants were only moderately fatigued by designing the 3D virtual environments with both e-scaffolding sources (teachers/peers). Some of our findings are consistent with the literature, and some are not. The agreement and disagreement are explained above.

This study may be used as a guide for teachers and instructional designers, helping them to select the most suitable e-scaffolding source when teaching 3D virtual environment design skills for better and easier skill development. The study also sheds light on the challenges of using technology and the importance of taking technology fatigue into account when delivering educational content through technology. In addition, the study may contribute to alerting educational institutions to the importance of the various e-scaffolding sources and their benefits and uses in education. The results of this study may draw the attention of the researchers in the fields of cyberpsychology and human–

computer interaction to one of their negative results, which is fatigue. The study confirms that receiving scaffolding, in general, reduces technology fatigue. Moreover, those in charge of designing virtual environments can benefit from the list of skills for designing 3D virtual environments.

This study also suggests further research on e-scaffolding sources in other environments, such as problem-based learning environments, flipped learning environments, and gamification-based learning environments. Moreover, the effects of e-scaffolding sources and different cognitive styles in a variety of learning environments on a number of learning outcomes may be explored. More studies on 3D virtual environments are also recommended, with other dependent variables such as motivation, achievement, student attitudes, and engagement. The literature on technology fatigue is still weak, and needs more attention.

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

Funding: This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (Project No. 401).

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki, and approved by the Research Ethics Committee at King Faisal University (KFU-REC-2022-MAR-EA000544).

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

Data Availability Statement: Not applicable.

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

References

1. Khlaisang, J.; Songkram, N. Designing a virtual learning environment system for teaching twenty-first century skills to higher education students in ASEAN. *Technol. Knowl. Learn.* **2019**, *24*, 41–63. [CrossRef]
2. Cowling, M.; Vanderburg, R. An interactive virtual reality physics instructional environment based on Vygotskian Educational Theory. In Proceedings of the ASCILITE's First Virtual Conference, Armidale, NSW, Australia, 30 November–1 December 2020; pp. 168–173. [CrossRef]
3. Li, X.; Yi, W.; Chi, H.L.; Wang, X.; Chan, A.P. A critical review of virtual and augmented reality (VR/AR) applications in construction safety. *Autom. Constr.* **2018**, *86*, 150–162. [CrossRef]
4. Romero-Rodríguez, J.M.; Aznar-Díaz, I.; Hinojo-Lucena, F.J.; Gómez-García, G. Mobile learning in higher education: Structural equation model for good teaching practices. *IEEE Access* **2020**, *8*, 91761–91769. [CrossRef]
5. Palincsar, A.S.; Fitzgerald, M.S.; Marcum, M.B.; Sherwood, C.A. Examining the work of "scaffolding" in theory and practice: A case study of 6th graders and their teacher interacting with one another, an ambitious science curriculum, and mobile devices. *Int. J. Educ. Res.* **2018**, *90*, 191–208. [CrossRef]
6. Bailenson, J.N. Nonverbal overload: A theoretical argument for the causes of Zoom fatigue. *Technol. Mind Behav.* **2021**, *2*, 1–16. [CrossRef]
7. Bennett, A.A.; Campion, E.D.; Keeler, K.R.; Keener, S.K. Videoconference fatigue? Exploring changes in fatigue after videoconference meetings during COVID-19. *J. Appl. Psychol.* **2021**, *106*, 330–344. [CrossRef]
8. Wiederhold, B.K. Connecting through technology during the coronavirus disease 2019 pandemic: Avoiding "Zoom Fatigue". *Cyberpsychol. Behav. Soc. Netw.* **2020**, *23*, 437–438. [CrossRef]
9. Williams, N. Working through COVID-19: 'Zoom' gloom and 'Zoom' fatigue. *Occup. Med.* **2021**, *71*, 164. [CrossRef]
10. Golu, F. Tech Fatigue-A new pandemic. *Studia Dr.* **2021**, *12*, 85–87. [CrossRef]
11. Krzic, M.; Wilson, J.; Hoffman, D. Scaffolding student learning: Forest floor example. *Nat. Sci. Educ.* **2018**, *47*, 17. [CrossRef]
12. Loparev, A. *The Impact of Collaborative Scaffolding in Educational Video Games on the Collaborative Support Skills of Middle School Students*; University of Rochester: Rochester, NY, USA, 2016. Available online: https://www.proquest.com/docview/1794167603?pq-origsite=gscholar&fromopenview=true (accessed on 26 May 2021).
13. Amelia, R.; Rofiki, I.; Tortop, H.S.; Abah, J.A. Pre-service teachers' scientific explanation with e-scaffolding in blended learning. *J. Ilm. Pendidik. Fis. Al-Biruni* **2020**, *9*, 33–40. [CrossRef]

14. Ebadi, S.; Beigzadeh, M. The effect of teacher scaffolding vs. peer scaffolding on EFL learners' reading comprehension development. *Int. J. Engl. Educ.* **2015**, *4*, 105–116. Available online: http://www.ijee.org/yahoo_site_admin/assets/docs/11.86141504.pdf (accessed on 12 January 2022).
15. Kivi, P.J.; Namaziandost, E.; Alamdari, E.F.; Saenko, N.R.; Inga-Arias, M.; Fuster-Guillén, D.; Sirisakpanich, D.; Nasirin, C. The Comparative Effects of Teacher Versus Peer-Scaffolding on EFL Learners' Incidental Vocabulary Learning and Reading Comprehension: A Socio-Cultural Perspective. *J. Psycholinguist. Res.* **2021**, *50*, 1031–1047. [CrossRef] [PubMed]
16. Karimi, L.; Jalilvand, M. The effect of peer and teacher scaffolding on the reading comprehension of EFL learners in asymmetrical and symmetrical groups. *J. Teach. Lang. Ski.* **2014**, *32*, 1–17. Available online: https://jtls.shirazu.ac.ir/article_1860_7d531b852ed556ae80d9ed4d2db4c077.pdf (accessed on 30 April 2021).
17. Kim, N.J.; Belland, B.R.; Axelrod, D. Scaffolding for optimal challenge in K–12 problem-based learning. *Interdiscip. J. Probl. Based Learn.* **2018**, *13*, 1831–1834. [CrossRef]
18. Könings, K.D.; van Zundert, M.; van Merriënboer, J.J. Scaffolding peer-assessment skills: Risk of interference with learning domain-specific skills? *Learn. Instr.* **2019**, *60*, 85–94. [CrossRef]
19. Mansouri, S.; Heidar, D.M. Peer/teacher technology-enhanced scaffolding through process approach and Iranian EFL learners' vocabulary knowledge: A probe into self-regulation. *Teach. Engl. A Second Lang. (Former. J. Teach. Lang. Ski.)* **2019**, *38*, 189–223. [CrossRef]
20. Sabet, M.K.; Tahriri, A.; Pasand, P.G. The impact of peer scaffolding through process approach on EFL learners' academic writing fluency. *Theory Pract. Lang. Stud.* **2013**, *3*, 1893. [CrossRef]
21. Saleh, A.; Silver, C.H.; Chen, Y.; Shanahan, K.; Rowe, J.; Lester, J. Scaffolding Peer Facilitation in Computer-Supported Problem-Based Learning Environments. In *Rethinking Learning in the Digital Age: Making the Learning Sciences Count, 13th International Conference of the Learning Sciences (ICLS) 2018, London, UK, 23–30 June 2018*; Kay, J., Luckin, R., Eds.; International Society of the Learning Sciences: London, UK, 2018; Volume 3. [CrossRef]
22. Shooshtari, Z.G.; Mir, F. ZPD, tutor; peer scaffolding: Sociocultural theory in writing strategies application. *Procedia-Soc. Behav. Sci.* **2014**, *98*, 1771–1776. [CrossRef]
23. Sun, L.; Ruokamo, H.; Siklander, P.; Li, B.; Devlin, K. Primary school students' perceptions of scaffolding in digital game-based learning in mathematics. *Learn. Cult. Soc. Interact.* **2021**, *28*, 100457. [CrossRef]
24. Abune, A.A. Effects of Peer Scaffolding on Students' Grammar Proficiency Development. *Online Submiss.* **2019**, *7*, 105–120. [CrossRef]
25. AlThiyabi, M.S.; Al-Bargi, A. The effect of teacher scaffolding on Learning English as a foreign language at King Abdulaziz University: A classroom discourse analysis. *Int. J. Educ. Investig.* **2016**, *3*, 1–20. Available online: http://www.ijeionline.com/attachments/article/55/IJEI.Vol.3.No.6.01.pdf (accessed on 3 December 2021).
26. Amerian, M.; Ahmadian, M.; Mehri, E. Sociocultural theory in practice: The effect of teacher, class, and peer scaffolding on the writing development of EFL learners. *Int. J. Appl. Linguist. Engl. Lit.* **2014**, *3*, 2. [CrossRef]
27. Hanjani, A.M. Collective peer scaffolding, self-revision, and writing progress of novice EFL learners. *Int. J. Engl. Stud.* **2019**, *19*, 41–57. [CrossRef]
28. Hsieh, Y.C. A case study of the dynamics of scaffolding among ESL learners and online resources in collaborative learning. *Comput. Assist. Lang. Learn.* **2017**, *30*, 115–132. [CrossRef]
29. Riazi, M.; Rezaii, M. Teacher- and Peer-Scaffolding Behaviors: Effects on EFL Students' Writing Improvement. In Proceedings of the 12th National Conference for Community Languages and ESOL, Dunedin, New Zealand, 1–4 October 2011; pp. 55–63. Available online: http://www.tesolanz.org.nz/ (accessed on 13 February 2022).
30. Shehadeh, A. Effects and student perceptions of collaborative writing in L2. *J. Second Lang. Writ.* **2011**, *20*, 286–305. [CrossRef]
31. Dabbagh, N. Scaffolding: An important teacher competency in online learning. *TechTrends* **2003**, *47*, 39–44. [CrossRef]
32. Shin, S.; Brush, T.A.; Glazewski, K.D. Examining the hard, peer, and teacher scaffolding framework in inquiry-based technology-enhanced learning environments: Impact on academic achievement and group performance. *Educ. Technol. Res. Dev.* **2020**, *68*, 2423–2447. [CrossRef]
33. Hou, H.T.; Keng, S.H. A Dual-Scaffolding Framework Integrating Peer-Scaffolding and Cognitive-Scaffolding for an Augmented Reality-Based Educational Board Game: An Analysis of Learners' Collective Flow State and Collaborative Learning Behavioral Patterns. *J. Educ. Comput. Res.* **2021**, *59*, 547–573. [CrossRef]
34. Lai, M.; Law, N. Peer scaffolding of knowledge building through collaborative groups with differential learning experiences. *J. Educ. Comput. Res.* **2006**, *35*, 123–144. [CrossRef]
35. Van de Pol, J.; Volman, M.; Beishuizen, J. Promoting teacher scaffolding in small-group work: A contingency perspective. *Teach. Teach. Educ.* **2012**, *28*, 193–205. [CrossRef]
36. Pifarre, M.; Cobos, R. Promoting metacognitive skills through peer scaffolding in a CSCL environment. *Int. J. Comput.-Supported Collab. Learn.* **2010**, *5*, 237–253. [CrossRef]
37. Khodamoradi, A.; Irvani, H.; Jafarigohar, M.; Amerian, M. Teacher's scaffolding vs. peers' collaborative dialogue: Im-plementing innovation in the sociocultural context of Iranian universities. *Middle-East J. Sci. Res.* **2013**, *14*, 1212–1220. [CrossRef]
38. Kuhoof, S.A.E. The impact of the interaction between the support source (teacher/peers) and the participating group Size (medium/large) in e-learning environment, BlackBoard, in developing the attitude towards it and the quality of creating e-tests for students at the faculty of Science and Arts in Sharurah. *J. Educ. Al-Azhar Univ.* **2020**, *188*, 291–356. Available online: https://journals.ekb.eg/article_146175.html (accessed on 26 May 2021).

39. Ozlem, O.Z.A.N. Scaffolding in connectivist mobile learning environment. *Turk. Online J. Distance Educ.* **2013**, *14*, 44–55.
40. El-Tabakh, H.A.; El-Moher, A.A. The effect of different support sources (teacher/peers) in the cloud learning environment on developing the skills of designing some web 2.0 applications for students of the Faculty of Specific Education. *Educ. J. Sohag Univ.* **2020**, *75*, 501–610. [CrossRef]
41. Huang, H.; Lin, C.; Cai, D. Enhancing the learning effect of virtual reality 3D modeling: A new model of learner's design collaboration and a comparison of its field system usability. *Univers. Access Inf. Soc.* **2021**, *20*, 429–440. [CrossRef]
42. Hussein, M.; Nätterdal, C. The Benefits of Virtual Reality in Education-A Comparison Study. Bachelor's Thesis, University of Gothenburg, Gothenburg, Sweden, 2015. Available online: https://gupea.ub.gu.se/bitstream/2077/39977/1/gupea_2077_39977_1.pdf (accessed on 15 December 2021).
43. Avcı, Ş.K.; Coklar, A.N.; İstanbullu, A. The effect of three dimensional virtual environments and augmented reality applications on the learning achievement: A meta-analysis study. *Egit. Bilim* **2019**, *44*, 149–182. [CrossRef]
44. Çoklar, A.N.; Sahin, Y.L. Technostress levels of social network users based on ICTs in Turkey. *Eur. J. Soc. Sci.* **2011**, *23*, 171–182.
45. Ghanbarzadeh, R.; Ghapanchi, A.H. Investigating various application areas of three-dimensional virtual worlds for higher education. *Br. J. Educ. Technol.* **2018**, *49*, 370–384. [CrossRef]
46. López, C.E.; Cunningham, J.; Ashour, O.; Tucker, C.S. Deep reinforcement learning for procedural content generation of 3d virtual environments. *J. Comput. Inf. Sci. Eng.* **2020**, *20*, 051005. [CrossRef]
47. Tilhou, R.; Taylor, V.; Crompton, H. 3D virtual reality in K-12 education: A thematic systematic review. *Emerg. Technol. Pedagog. Curric.* **2020**, *2020*, 169–184. [CrossRef]
48. Alghamdi, M.; Regenbrecht, H.; Hoermann, S.; Swain, N. Mild stress stimuli built into a non-immersive virtual envi-ronment can elicit actual stress responses. *Behav. Inf. Technol.* **2017**, *36*, 913–934. [CrossRef]
49. Tseng, W.T.; Liou, H.J.; Chu, H.C. Vocabulary learning in virtual environments: Learner autonomy and collaboration. *System* **2020**, *88*, 102190. [CrossRef]
50. Glaser, N.J.; Schmidt, M. Usage considerations of 3D collaborative virtual learning environments to promote develop-ment and transfer of knowledge and skills for individuals with autism. *Technol. Knowl. Learn.* **2020**, *25*, 315–322. [CrossRef]
51. Cantey, D.S.; Sampson, M.; Vaughn, J.; Blodgett, N.P. Skills, community, and rapport: Prelicensure nursing students in the virtual learning environment. *Teach. Learn. Nurs.* **2021**, *16*, 384–388. [CrossRef]
52. Carvalho Mano, R.M. The benefits of Virtual Reality in Education. Ph.D. Thesis, Hochschule für Angewandte Wis-senschaften Hamburg, Hamburg, Germany, 2019. Available online: https://reposit.haw-hamburg.de/bitstream/20.500.12738/8592/1/thesis.pdf (accessed on 28 February 2022).
53. Kinateder, M.; Ronchi, E.; Nilsson, D.; Kobes, M.; Müller, M.; Pauli, P.; Mühlberger, A. Virtual reality for fire evacuation research. In Proceedings of the 2014 Federated Conference on Computer Science and Information Systems, Warsaw, Poland, 7–10 September 2014; pp. 313–321. [CrossRef]
54. Boyles, B. *Virtual Reality and Augmented Reality in Education. Center for Teaching Excellence*; United States Military Academy: West Point, NY, USA, 2017. Available online: https://www.westpoint.edu/sites/default/files/inline-images/centers_research/center_for_teching_excellence/PDFs/mtp_project_papers/Boyles_17.pdf (accessed on 23 January 2022).
55. Wu, H.K.; Lee, S.W.Y.; Chang, H.Y.; Liang, J.C. Current status, opportunities and challenges of augmented reality in education. *Comput. Educ.* **2013**, *62*, 41–49. [CrossRef]
56. Schroeder, N.L. Pedagogical agents for learning. In *Emerging Tools and Applications of Virtual Reality in Education*; Choi, D.H., Dailey-Hebert, A., Estes, J.S., Eds.; IGI Global: Hershey, PA, USA, 2016; pp. 216–238. [CrossRef]
57. Pantelidis, V.S. Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. *Themes Sci. Technol. Educ.* **2010**, *2*, 59–70.
58. Wujcik, D.M. When technology fatigue kicks in, rely on experts to lead the way. *ONS Connect.* **2011**, *26*, 5.
59. Molino, M.; Ingusci, E.; Signore, F.; Manuti, A.; Giancaspro, M.L.; Russo, V.; Zito, M.; Cortese, C.G. Wellbeing costs of technology use during Covid-19 remote working: An investigation using the Italian translation of the technostress creators scale. *Sustainability* **2020**, *12*, 5911. [CrossRef]
60. Palumbo, R. Let me go to the office! An investigation into the side effects of working from home on work-life balance. *Int. J. Public Sect. Manag.* **2020**, *33*, 771–790. [CrossRef]
61. Fitzgerald, N. The Influence of Technostress on Perceived Academic Performance: A Study on University Students in Sweden. Bachelor's Thesis, Malmö University, Malmo, Sweden, 2021. Available online: https://www.diva-portal.org/smash/get/diva2:1528770/FULLTEXT01.pdf (accessed on 15 January 2022).
62. Shu, Q.; Tu, Q.; Wang, K. The impact of computer self-efficacy and technology dependence on computer-related tech-nostress: A social cognitive theory perspective. *Int. J. Hum.-Comput. Interact.* **2011**, *27*, 923–939. [CrossRef]
63. Ayyagari, R. Impact of information overload and task-technology fit on technostress. In Proceedings of the Southern Association for Information Systems Conference, Seattle, WA, USA, 23–24 March 2012; pp. 18–22. Available online: https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1003&context=sais2012 (accessed on 18 March 2022).
64. Sass, T.; Goldring, T. *Student Achievement Growth During the COVID-19 Pandemic*; Georgia State University: Atlanta, GA, USA, 2021. Available online: https://gpl.gsu.edu/publications/student-achievement-growth-during-the-covid-19-pandemic/ (accessed on 10 November 2021).

65. Lee, A.R.; Son, S.M.; Kim, K.K. Information and communication technology overload and social networking service fatigue: A stress perspective. *Comput. Hum. Behav.* **2016**, *55*, 51–61. [CrossRef]
66. Okonoda, K.M.; Tagurum, Y.O.; Imo, C.O.; Nwachukwu, V.A.; Okoli, E.S.; James, B.O. Prevalence and correlates of technostress among academic staff at the University of Jos, Nigeria. *J. Med. Sci. Clin. Res.* **2017**, *5*, 18616–18624. [CrossRef]
67. Al Mulhim, E.N. Technology Fatigue during the COVID-19 Pandemic: The Case of Distance Project-Based Learning Environments. *Turk. Online J. Distance Educ.* 2022, *in press*.
68. Halupa, C.; Bolliger, D.U. Technology Fatigue of Faculty in Higher Education. *J. Educ. Pract.* **2020**, *11*, 16–26. [CrossRef]
69. Lazarus, R.S.; Folkman, S. *Stress, Appraisal, and Coping*; Springer Publishing Company: New York, NY, USA, 1984.
70. Cooper, C.L.; Cooper, C.P.; Dewe, P.J.; Dewe, P.J.; O'Driscoll, M.P.; O'Driscoll, M.P. *Organizational Stress: A Review and Critique of Theory, Research, and Applications*; SAGE Publications, Inc.: Newbury Park, CA, USA, 2001. [CrossRef]
71. Karr-Wisniewski, P.; Lu, Y. When more is too much: Operationalizing technology overload and exploring its impact on knowledge worker productivity. *Comput. Hum. Behav.* **2010**, *26*, 1061–1072. [CrossRef]
72. Moore, J. One road to turnover: An examination of work exhaustion in technology professionals. *MIS Q.* **2000**, *24*, 141–168. [CrossRef]
73. Branch, B.M. *Instructional Design: The ADDIE Approach*; Springer: New York, NY, USA, 2009. [CrossRef]
74. Shapiro, S.S.; Wilk, M.B. An analysis of variance test for normality (complete samples). *Biometrika* **1965**, *52*, 591–611. [CrossRef]
75. Cramer, D. *Fundamental Statistics for Social Research: Step-by-Step Calculations and Computer Techniques Using SPSS for Windows*, 1st ed.; Routledge: London, UK, 1997. [CrossRef]