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VR-Based Teacher Training Environments: A Systematic Approach for Defining the Optimum Appearance of Virtual Classroom Environments

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Abstract: Virtual Reality (VR) technology has the potential to provide end-user teachers with highly engaging and immersive experiences that reflect real-life classroom challenges and, at the same time, offer a safe space for hands-on practice and experimentation, allowing mistakes without potential consequences to the class or the fear of affecting actual students. The appearance of the virtual environment is a significant component of user experience, and a carefully designed virtual environment customized to meet the needs of end-users can considerably enhance their experience. This paper aims to reflect on the co-design journey of a VR-based teacher training solution designed by teachers, for teachers. Teachers were actively engaged as co-designers throughout all phases of design—conceptualization, development, testing, and iteration—to ensure that the final VR training tool is aligned with their actual needs and preferences, maximizing the added value and acceptance of the virtual solution. The paper presents findings from a series of user engagement activities, highlighting the diverse perspectives of teachers and the design insights gained from their involvement. Teachers who spend a significant amount of time in classrooms may benefit more from an imaginative space rather than a standard classroom environment. The findings indicate that imaginary virtual classroom settings generate high levels of presence, indicating that users may look for experiences that break from the ordinary.

Keywords: virtual reality; co-design; user involvement; teacher training

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1. Introduction

As technology rapidly evolves, teachers are constantly exploring new and innovative training tools to enhance their teaching and learning experiences. Among these advancements, Virtual Reality (VR) has emerged as a transformative tool that simulates a three-dimensional environment in a way that closely resembles real-world experiences. VR is defined as a "computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside" [1]. VR "simulates a virtual environment that immerses users to the extent that they have the feeling of "being there" [2]. This feeling of presence gives users the "illusion" that the virtual space within which they are located truly exists, while the immersive experience allows users to interact with the digital elements as if they were part of the real world [3].

Current technological progress has promoted the evolution of many professional and high-quality Virtual Reality (VR) training applications across various domains [4–6], including tourism [7], medicine [8–10], rehabilitation [11,12], education [13–19], firefighter training [20,21], police training [22], architecture [23], and more. Many of these applications incorporate multiple functions; however, their design often ignores the actual needs and preferences of end-users [24]. While these systems demonstrate technical accuracy and functionality, end-users may find them unappealing, encounter various usability challenges, or perceive them as lacking added value [25].

From the idea generation stage to the development of a VR application, understanding the real needs and preferences of end-users is imperative. End-users play a crucial role in shaping an effective and high-value VR experience, and the diversity of their needs, characteristics, experiences, and capabilities generates a unique and personalized experience within the virtual space [26]. VR environments and systems should be designed with an emphasis on integrating users' actual needs, preferences, and perspectives, as end-users are the ones who eventually interact with the virtual space.

The current paper presents the process of designing a novel VR prototype application for immersive teacher training. Integrating VR in teacher training represents a significant opportunity for promoting teachers' personal and professional development through hands-on experiential training. One of the most important challenges in teacher education is the lack of on-the-job practice in schools and the school-university disconnection [27–29]. VR technology can provide teachers with a safe space for experiential training and reflection without the constraints of traditional classroom settings [30]. One of the most compelling advantages of integrating VR into teacher training is the ability to replicate real-life scenarios that educators may encounter in the classroom [16]. This immersive VR-based approach allows teachers to experience, practice, reflect, and refine their skills in realistic, life-like classroom settings and scenarios without the potential risks associated with actual classroom situations. Equally important is that teachers can receive real-life feedback on their practice, while the lessons learned during the VR experience can be transferred to real life [17,31,32]. By immersing teachers in real-life scenarios through VR-based approaches, they are provided with a unique opportunity to experience situations that reflect the complexities and challenges of today's dynamic classrooms, allowing them to step into multiple roles and change perspectives, enhancing their confidence, preparedness, and self-efficacy, leading to the effective handling of classroom practices [16,18].

The design and development of the proposed VR-based training solution followed a structured process, starting with research and needs identification and progressing to conceptualizing the idea for VR-based training. Throughout the project life cycle, education professionals, including teachers, school counsellors, psychologists, and higher education students representing the future generations of teachers, contributed to the design of the VR environment, particularly the fantastic space. Additionally, end-users evaluated various virtual spaces multiple times throughout the process, providing feedback on each iteration. Furthermore, these stakeholders pilot-tested multiple versions of the VR-based training solution, providing significant insights that led to refinements of the VR training solution, shaping the final deliverable.

Despite the acknowledged benefits of co-design, there remains a gap in the literature regarding its implementation within the development of VR-based training solutions for teacher education. Co-design approaches are often proposed in theory as a method to create tools and solutions in partnership with end-users. However, in practice, fully engaging target audiences such as teachers can be challenging. Teachers, for example, have demanding schedules, diverse needs, and may face institutional constraints, making it difficult for them to participate actively in every phase of the design process. As a result,

co-design efforts sometimes focus on gathering input or feedback rather than establishing a true collaboration throughout the project. As a result, design solutions might often lack the depth of insight that true co-design could provide. To bridge this gap and deliver a VR-based professional teacher training solution with enhanced value for teachers, end-users contributed to each phase of the project, spanning from the identification of real daily classroom needs and challenges and the initial design phase to the pilot testing and evaluation of the VR training prototype. This approach made teachers feel in control and like co-designers throughout the design process, fostering a sense of ownership and leading to the development of high-quality and added-value VR training tools aligned with their needs and preferences [33,34].

From the outset, it became evident that teachers' unfamiliarity with VR technologies was an important consideration, but their primary focus was not on the technical aspects of the VR system itself. Instead, what proved to be considerably more significant for teachers was the training scenario and its added value, the impact of the training on their personal and professional development, and the feedback provided after the VR-based training. Since the VR-based training tool is designed for teachers, the training scenarios must reflect daily classroom challenges that they face and not just replicate educational theory. Teachers want VR-based training experiences that present situations they commonly face, such as managing student behavior or dealing with unexpected classroom incidents. The added value of the VR training experience lies in its ability to replicate challenging classroom situations within a safe and controlled space, enabling hands-on practice, experimentation with different strategies, and even making mistakes without potential consequences to the class or the fear of affecting actual students.

Although the appearance of the virtual classroom environment was not initially a focus of the research, it quickly emerged as an important factor to consider. Many teachers expressed a preference for environments that were not real-life replicas, as they did not want the virtual experience to reflect their everyday classroom setting. Teachers' involvement in the design of the 3D virtual classroom space provided valuable insights, offering a new perspective on the design of the virtual environment, leading to the development of a training tool by them, for them. The visual design of the virtual space is closely tied to key elements like presence and immersion, which significantly affect the overall experience. A carefully designed space that aligns with teachers' preferences can significantly enhance their sense of presence and immersion, ultimately improving the effectiveness and perceived value of the VR training tool.

The paper demonstrates how teacher involvement and co-design shaped the visual and aesthetic aspects of the virtual environment. Their contributions directly influenced the development of the virtual classroom space, the development of the scenarios, and the final VR training solution. Unlike many VR educational tools designed with student engagement in mind, the proposed VR-based training solution is developed specifically for teachers with the aim of addressing the unique challenges of the classroom and promoting the professional growth of both pre-service and in-service teachers. By involving teachers throughout the design and development process, the paper underscores the importance of customizing virtual environments to align with teachers' needs and presents findings that suggest high-fidelity, real-life realistic environments may not always be the most immersive or effective for teacher training. Teachers' preferences for fictional virtual classroom spaces represent a novel perspective in VR training for educators and suggest that imaginative settings may enhance presence and immersion, supporting professional growth in unique ways.

The paper seeks to share the valuable lessons learned throughout this journey of designing the VR training solution collaboratively with teachers, providing insights and

knowledge to the broader research community. By sharing these experiences, the authors aim to contribute to the existing body of knowledge concerning the design of VR-based teacher training solutions and also inspire future research and advancement of VR-based training tools that promote the personal and professional development of teachers. The remainder of the paper is organized as follows: Section 2 presents the state of the art concerning co-design with end-users and how co-design can be applied in the context of VR. This is followed by the presentation of the methodological framework and steps of the current research, an in-depth discussion of the results, and a conclusion summarizing the most important insights.

2. Co-Designing Virtual Training Experiences and Applications with End-User Insights

Co-designing virtual training experiences and solutions with end-user insights is a process that requires a deep understanding of user needs, preferences, and expectations. This section reflects on the importance of integrating end-users' insights and perspectives into the development process of a VR-based training solution.

2.1. Integrating User Preferences in Virtual Reality (VR) Design

In the past, developers and end-users were considered two separate groups with different roles, backgrounds, and spoken language [35]. Traditionally, developers create software, systems, products, applications, and more that, at the end of the design cycle, are pilot-tested, evaluated, and used by end-users [36,37]. Lately, those traditional roles have evolved, with end-users shifting from passive consumers to active participants, contributing significantly to the design and development processes and shaping the final deliverables [36,38]. Although most end-users do not possess programming or technical skills, their expertise in their work domain and their deep understanding of the daily challenges they face make their input a necessity in the design and development process [36]. Their unique perspective ensures that designs are aligned with actual problems, making their contributions a necessary component of effective solution-building.

User involvement, often referred to as co-design, "allows users to become part of the design team as experts of their experience" [39]. Co-design is based upon the principle that the end-users who will use a product, service, or system possess valuable insights and are experts in their own experiences and perspectives, which can enrich the design process [40]. Users play a significant role in driving the design process as they can teach designers how to design training solutions that address real needs and preferences. Co-design emphasizes collaboration and equal partnership between designers, developers, and end-users [38–40]. This approach recognizes that end-users are "active partners" [41], experts in their own experiences, and should view themselves as active contributors in the decision-making processes at all stages of the design phase. Additionally, co-design promotes a sense of ownership and shared responsibility among all stakeholders participating in the design process [33,34,41].

The initial phase in designing a VR-based training system involves obtaining a deep understanding of end-users' real needs, encompassing their preferences, requirements, objectives, attitudes, behaviors, cultural context, the languages they are familiar with, and more [36,37,42,43]. Users "are experts of the work domain so a system can be effective only if these experts are allowed to participate in its design, indicating their needs and expectations" [36]. For instance, during the development of a VR-based tool for teacher training, it is crucial for the system to be responsive to teachers' capabilities and aligned with training objectives. Moreover, it is of paramount importance to actively engage not only the primary target audience—in this case, teachers—but also secondary audiences,

such as school counsellors, students, and ICT experts in the co-design process, as they can provide valuable insights. This can lead to the development of training tools that not only meet the specific needs and requirements of teachers, but also ensure usability and effectiveness for a diverse range of individuals within the educational environment [44,45].

When creating a VR system tailored for teachers, understanding their perspectives becomes essential [46]. Their engagement throughout the entire process of designing and developing the VR training system (design, development, implementation, and evaluation) is pivotal, resulting in the delivery of high-quality and efficient VR systems that align with their needs and are integrated into their daily routine [37,38,44,47]. Furthermore, involving domain experts, such as teachers, in the design of a VR training solution will address developers' lack of domain knowledge, ensuring informed design decisions that match users' needs and preferences [25,48,49].

2.2. User-Assisted Design for Educational VR Experiences

In the realm of educational VR training solutions, a well-established framework to guide the design, development, and evaluation phases is essential to ensure the value of the deliverable [31]. Despite the necessity of teachers' involvement in the design and development of VR-based training solutions, there is a lack of their participation, resulting in many VR applications that are not aligned with the curriculum and their needs. A way to ensure the design of effective and high-quality VR-based training solutions is through the joint effort of developers and education professionals (domain experts), working together as co-designers toward the creation of VR applications that are not only technically sound but also add value to educational settings [36,50–53]. Crosier et al. [51] suggest involving education professionals right from the idea generation stage, given that their insights are significant for shaping the design and development of effective and valuable training solutions that are tailored to their classroom needs. Moreover, according to Crosier et al. [50] and Goertzen et al. [54], teachers' contributions throughout the design and development process will foster their "sense of ownership", maximizing the added value of the tool, and thus ensuring its implementation within the classroom. Furthermore, the authors emphasize the need to provide guidelines to designers and developers of educational VR systems, and they share the lessons learned from the method they used (selection, design and development, and evaluation). The authors stress the importance of aligning with real teaching and learning needs to prevent challenges such as inadequate user interaction, poor engagement, and low performance. Even the most creative educational solution will remain unused if it does not align with teaching methods, student learning needs, and curricular requirements [25]. The following section presents the methodological framework and the steps that were followed to co-design the proposed VR application with the target audience.

3. Methodological Framework

This paper employs a case study approach to present insights from a project that aimed to explore the integration of VR-based training approaches to enhance teachers' soft skills, such as empathy.

3.1. Co-Designing a VR Training Solution for Teacher Training

This project aimed to explore the potential of designing, developing, and implementing a VR-based tool to support the personal and professional development of teachers, addressing the need for hands-on training. The project sought to delve into the capabilities of using VR as a training solution to bridge the gap between theory and practice in teacher training and reshape traditional teacher education practices, fostering digital transformation and modernization. The design process followed the User-Centered Design (UCD)

methodology, ensuring that end-users are at the forefront of designing the VR training solution. This approach focuses on understanding their needs, preferences, and experiences, ensuring that the final deliverable is aligned with those needs and provides high added value [36,55–57].

In light of this iterative process and the need to involve education professionals in the process, a mixed-methods, multiphase design approach was selected as the most suitable. Initially, end-users' needs were identified through surveys and interviews to gain an in-depth understanding of their challenges [17]. Empathizing with end-users allowed for brainstorming and prototyping potential VR-based solutions. The VR prototypes were pilot-tested to evaluate initially the design of the virtual space and its impact on user immersion, and, in the long-term, the impact of the VR-based training on teachers' competencies [58,59]. The steps followed for the design of the VR classroom space are presented in Figure 1.

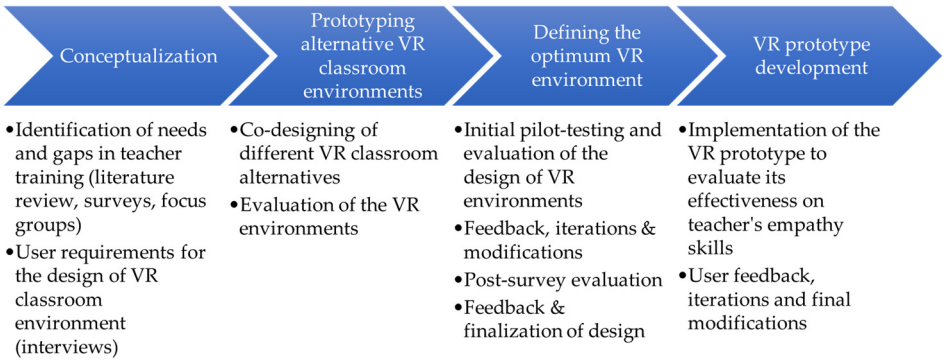


Figure 1. The main steps of the co-design process of designing the VR classroom environment.

The research protocol was reviewed and approved by the Cyprus University of Technology Bioethics Committee (ref. 2019_20_11/84). Prior to participation, all participants were provided with detailed information about the study objectives, procedures, potential risks, and benefits. Informed consent was obtained from each participant following ethical guidelines.

The next section focuses on presenting the steps of the co-design process followed by the design of the VR environment with input from teachers. It should be noted that this paper refers only to the design of the virtual space. The implementation of the final VR training application and its effectiveness on teachers' competencies are beyond the scope of this paper [60,61].

3.2. Virtual Reality Environment Co-Design Process

The design of the VR environment was a pivotal phase of this project to provide users with an immersive, engaging, and unique VR-based training experience for their personal and professional development. Initially, the virtual classroom space was envisioned to accurately replicate a real-life classroom setting familiar to the users. However, during the co-design process, user input through interviews indicated an alternative path, leading to the design of a fictional virtual classroom space. Both virtual spaces designed and developed were evaluated by end-users via multiple tools, including questionnaires, electroencephalogram (EEG) tools, interviews, and surveys, and the input gathered informed several iterations and modifications, shaping the development of the optimum VR environment for the prototype application.

The following sections present the process of designing the two different virtual classroom settings (lifelike and fictional) and the experimental investigation of the user acceptance of each alternative design.

3.2.1. Lifelike-Based Virtual Classroom Environment

A key aspect during the design of the VR classroom environment was achieving a high level of fidelity, aiming to create a familiar space that would evoke a strong sense of presence, giving teachers the illusion of actively participating within the virtual classroom environment [58,59]. To achieve authenticity, the 3D models were designed based on photographs captured in real classrooms (Figure 2).

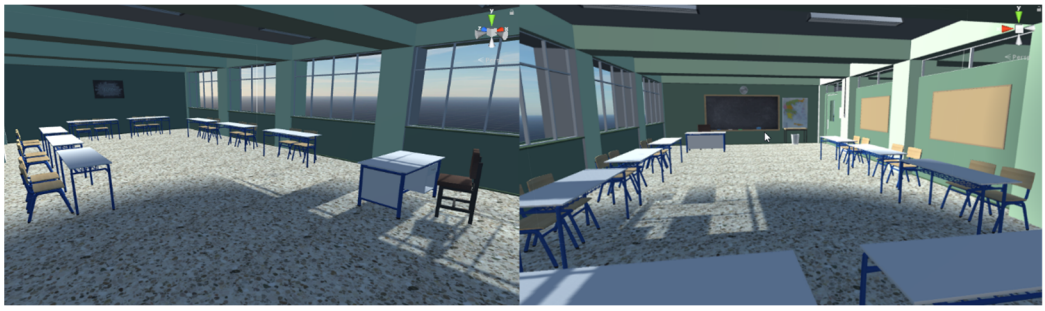


Figure 2. Lifelike virtual classroom environment.

3.2.2. Fictional Virtual Classroom Environment

During the initial design stages, the involved teachers put forth an alternative viewpoint that the virtual classroom should not replicate reality but rather a more fictional setting. The rationale behind this perspective stems from the fact that teachers spend significant hours in their actual classroom; hence, in a virtual classroom training space, they prefer a more fictional environment. These different perspectives influenced the development of a fictional classroom space to further explore potential differences between the two.

The fictional virtual classroom was designed based on the insights derived during interviews with teachers, where participants suggested that the ideal classroom should be colorful and surrounded by natural elements. Moreover, one of the teachers suggested the design of semicircular and colorful student desks to facilitate both individual and collaborative work, depending on the nature of the task. Drawing inspiration from these suggestions, the imaginary classroom took shape within the Maya software, while the 3D model of the classroom was inspired by greenhouses (see Figure 3).

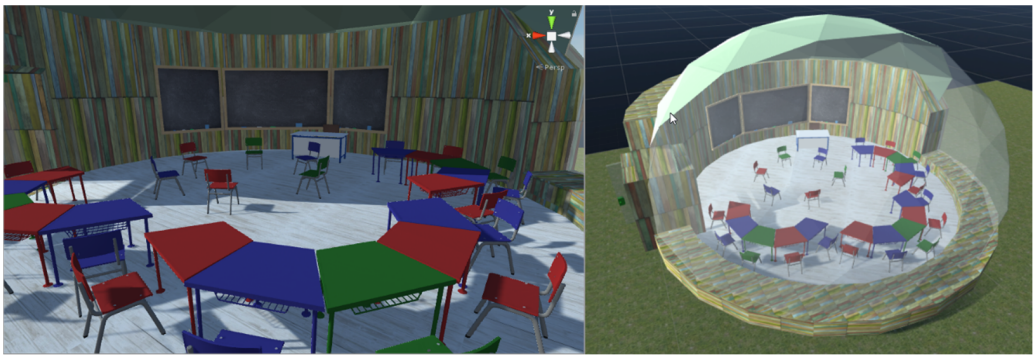


Figure 3. Fictional virtual classroom space.

3.3. Evaluation Framework of the VR Environments

This section delves into the experiments and survey conducted to identify potential disparities between the two virtual classrooms designed.

Real-Life vs. Fictional VR Environment: Experimental Design

The focus of the initial experiment was to explore participants' sense of presence within the two virtual environments (lifelike and fictional), assess any notable differences between them, and make iterative modifications to the virtual environment based on these insights.

a. Research objective and research questions

The initial study aimed to assess the sense of presence in lifelike-based and fictional virtual classroom environments. To address this objective, the following research hypothesis was formulated:

RH1. *Users feel more present in a lifelike virtual classroom environment than in a fictional virtual classroom environment.*

To address the stated objective and research hypothesis, a questionnaire was employed as the primary instrument for data collection. Additionally, an EEG device was used to measure participants' brain activity, enabling an investigation into potential differences in the electrical activity in the brains of users between the two Virtual Reality Environments (VREs). This dual-method approach aimed to provide comprehensive insights into participants' experiences and physiological responses within distinct virtual classroom settings.

b. Classroom scenes and groups

During the initial pilot testing, two virtual classroom scenes were used: (1) Lifelike virtual classroom environment and (2) fictional classroom environment (Figure 4). The scenario focuses on multiculturalism and verbal bullying. It begins with a teacher in the classroom alongside five students. The teacher introduces a new international student, Lynn, to the class. After her introduction, Lynn faces verbal bullying from some of her classmates.

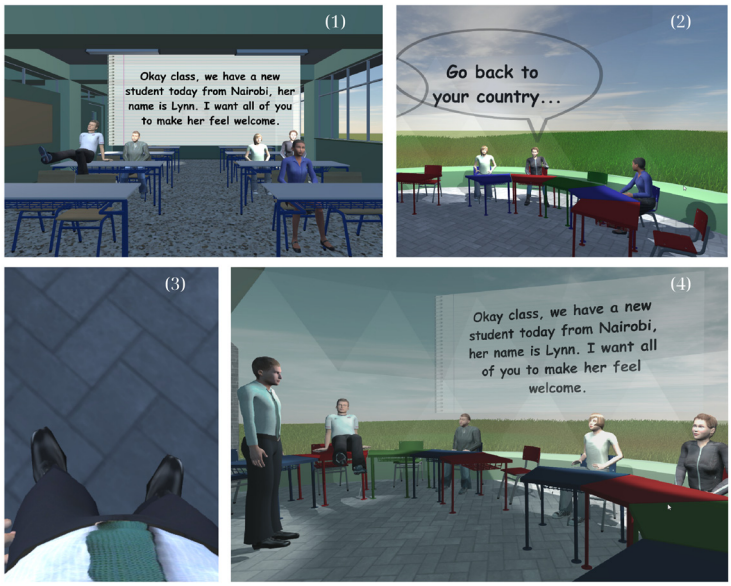


Figure 4. Categorization of the groups based on the classroom setting: (**1**) Group 1—Lifelike virtual classroom/From the teacher's perspective; (**2**) Group 2—Fictional virtual classroom/From the teacher's perspective; (**3**) Teacher's avatar; (**4**) Group 2—Fictional virtual classroom/From the eyes of Lynn.

The participants were divided randomly into two groups, each consisting of 11 individuals. Each group was trained using a different classroom setting, encountering either

the lifelike or the fictional environment as described above. Despite the setting differences, the scenario remained consistent for both groups: participants encountered an incident of verbal bullying within the classroom. The participants experienced the scenario from two viewpoints: first, from the teacher's perspective, observing the bullying through his eyes, and then from Lynn's perspective, with identical dialogues but different camera angles revealing the incidents from each viewpoint.

c. The instruments

Multiple instruments were used to assess the two virtual classrooms designed (lifelike and fictional). Following the pilot testing, the participants were asked to respond to questions from the Igroup Presence Questionnaire (IPQ), which is used for measuring the sense of presence (https://www.igroup.org/pq/ipq/index.php, accessed on 9 March 2023). Additionally, the BIOSEMI Active Two 64-channel amplifier system was used to measure the sense of presence, given its established reliability in presence measurement. The research aimed to identify potential transitions from the beta-wave state (13–25 Hz) to the alpha-wave state (8–12 Hz), a correlation related to the feeling of presence in virtual environments. In terms of VR equipment, HTC VIVE Virtual Reality Head-Mounted Displays were used.

d. The participants

The two groups, each consisting of 11 participants from the higher education sector, had different gender and age distributions. Group 1 included 9 males and 2 females, with an age range of 18 to 59 years. Group 2 comprised 7 males and 4 females, with an age range of 25 to 59 years. The two groups differed in their familiarity with VR. Participants in group 1 generally had low to moderate familiarity, with most reporting limited experience. In group 2, familiarity was also low, though a slightly higher number of participants reported no prior experience with VR.

e. Quantitative results

A reliability analysis was conducted on the presence scale, revealing an overall alpha coefficient of 0.715, exceeding the recommended threshold of 0.7, suggesting a high level of reliability for the IRI scale.

In terms of the overall sense of presence, the results presented in Table 1 indicated satisfactory levels of presence for both VR groups. Notably, Group 1 achieved a higher score (M = 4.4, SD = 1.29) compared to Group 2 (M = 3.6, SD = 1.86). The outcomes indicate a stronger sense of presence among participants who experienced the lifelike virtual classroom environment.

Table 1. IRI scale results.

Measure	Group 1 (M, SD)	Group 2 (M, SD)
Overall Sense of Presence	4.4, 1.29	3.6, 1.86
Spatial Presence	3.6, 2.16	3.5, 1.64
Perception Beyond Images	3.3, 1.68	3.9, 2.14
Involvement in Physical Space	3.1, 1.92	2.3, 2.24
Awareness of Real Surroundings	2.7, 1.57	4.7, 1.86
Experienced Realism	3.8, 1.62	3.1, 1.51

Regarding spatial presence, which refers to the perception of being physically located in the VR classroom environment, based on the results, participants in both groups reported experiencing a moderate sense of physical presence in the virtual classroom space (Group 1 M = 3.6, SD = 2.16, and Group 2 M = 3.5, SD = 1.64). Additionally, the results indicate

that participants did not just feel their VR experience as perceiving just images (Group 1 M = 3.3, SD = 1.68, and Group 2 M = 3.9, SD = 2.14).

According to the results, the participants noted that their interaction in the virtual space was limited (Group 1 M = 2.2, SD = 1.17, and Group 2 M = 2.7, SD = 1.43). This lack of perceived activity might stem from the limited interaction during the scenario, as this initial study aimed to evaluate the visual appeal of both virtual classroom environments designed and the sense of presence levels to identify potential differences that would determine which virtual classroom environment would be used for the final deliverable. It is also worth noting that a more interactive scenario could potentially enhance the sense of presence, but this consideration needs to be balanced against the sensitivity of the 64 electrodes used for EEG recordings.

In terms of involvement, the participants were not completely disconnected from physical space (Group 1 M = 3.1, SD = 1.92, and Group 2 M = 2.3, SD = 2.24). Additionally, the outcomes demonstrate a notable statistical difference between the two groups concerning their focus on the real physical environment. Individuals in Group 1 tended to be more aware of their real surroundings (M = 2.7, SD = 1.57), while individuals in Group 2 leaned toward disagreement (M = 4.7, SD = 1.86). These findings indicate that participants in Group 2 were more immersed in the virtual classroom environment compared to those in Group 1.

Regarding Experienced Realism, participants in Group 2 adopted a neutral position regarding the level of realism in the virtual classroom space(M = 3.1, SD = 1.51), while Group 1 tended to perceive the virtual world as unreal (M = 3.8, SD = 1.62). This observation serves as another indication that end-users were less satisfied with the lifelike virtual classroom environment that replicated a typical classroom setting, while they exhibited a more positive attitude toward the fictional classroom environment (Table 1).

According to the Mann–Whitney test, there were no statistically significant differences between the two groups in terms of the sense of presence. However, for the statement 'I still paid attention to the real environment', the p-value of $0.014 < 0.05$, indicating a noteworthy difference between groups 1 and 2. This particular statement addresses participants' immersion levels in the VR classroom environment. For Group 1, the mean score of 2.6 (SD = 1.57), indicates that participants tend to demonstrate a moderate awareness of the real environment while immersed in the VR lifelike classroom. On the contrary, for Group 2, the mean of 4.6 (SD = 1.86), suggests that participants demonstrate 'slightly' to 'poorly' awareness of the real environment while being immersed in the VR fictional classroom. The results suggest that participants in Group 2 demonstrated higher levels of immersion in the fictional VR classroom environment when compared to those who experienced the lifelike VR classroom.

Based on the results, the hypothesis was not fully supported. Despite the higher realism and perceived presence in the lifelike environment, the fictional VR classroom led to greater immersion, contrary to what might be expected based on the initial hypothesis.

As mentioned earlier, Electroencephalography (EEG) was also used as a research tool to record the electrical signals of participants' brains through electrodes placed on their scalps (Figure 5). The results obtained from the EEG device confirmed the conclusions drawn from the IPQ questionnaire. Both groups demonstrated synchronization in the alpha state, which is associated with the sense of presence (reference to be added after review to preserve anonymity), confirming questionnaire results. A notable finding from the EEG results was the synchronization of both groups in a theta state within the frontal region, which is associated with cognitive and mental states and working memory processes. Frontal theta has been linked to sustained attention and focus; hence, this synchronization suggests cognitive effort and represents attentional processing [59]. Despite the limited

interaction designed to avoid potential EEG signal interference from participant movements, the scenario effectively activated cognitive processes.



Figure 5. The three virtual environments under evaluation and their mean scores (MS): Lifelike VR classroom (**Left**); Fictional classroom environment (**Center**); and Fictional monumental environment (**Right**).

Furthermore, differences were noted in the occipital lobe, the brain's visual processing center. Only Group 2 achieved synchronization in the alpha band, indicating differences in visual attention mechanisms between the two groups. The results indicate that Group 1 experienced a more familiar, lifelike VR classroom environment, reducing the need to process many new features. In contrast, Group 2 experienced a fictional VR classroom space that triggered the processing of unfamiliar aspects. The differences observed in the occipital lobe in the EEG data between the two groups experiencing different VR environments could suggest variations in visual processing or attentional mechanisms associated with the specific characteristics of each VR environment. For example, differences in brightness, colors, or complexity of visual elements could contribute to distinct patterns of activity in the occipital lobe. The fact that the imaginary VR environment was more colorful may explain the observed differences in the occipital lobe activity in the EEG data. The occipital lobe may also reflect different engagement levels between the two VR environments. Individuals might have different preferences or levels of comfort with the visual elements presented in each VR environment. The results of the first experiment suggest that a sense of presence was achieved in both differently designed VR classroom environments [58]. These findings were further validated by the EEG results [59]. Users achieved higher levels of immersion in the fictional VR classroom, feeling more detached from the physical space they were located in. An important discovery from the EEG results was the differences in the occipital lobe for Group 2, which experienced the fictional classroom space. The occipital lobe, responsible for visual processing, showed distinctive activity. It seems that the fictional design of the virtual classroom effectively captured participants' visual attention mechanisms, as they interacted with an unfamiliar classroom environment that demanded exploration and processing. In summary, the achieved sense of presence was consistent across multiple measures, reinforcing the success of the virtual environments.

3.4. Post-Experiment Survey

The findings from the initial experiment revealed that the fictional VR classroom led to greater immersion, indicating a more complex relationship between presence and the design of the virtual classroom environment. Additionally, post-experiment interviews with participants highlighted diverse views, with some advocating for a lifelike virtual classroom space, reflecting their daily routine and providing a sense of familiarity and comfort. However, others argued for a more relaxing and fictional virtual classroom environment for hands-on training after their working hours. To further investigate the visual appeal of the virtual classroom, an online survey was conducted to delve into

teachers' preferences for the virtual classroom space. This section outlines the details of this survey.

a. Research question and instrument

The survey aimed to delve into teachers' preferences and expectations for the appearance of the virtual classroom. In line with this objective, the following research hypothesis was formulated:

RH. *Teachers would prefer hands-on training in a virtual classroom environment that replicates a lifelike classroom over a fictional virtual space.*

To further explore the research hypothesis, a new virtual scene was developed representing a fictional space, in addition to the two previously created virtual classroom environments (lifelike and fictional). This new scene aimed to provide a broader comparison between the lifelike and fictional virtual environments to better understand teachers' preferences for hands-on training. The questionnaire developed consisted of four sections. The first section gathered demographic data. The second section focused on investigating participants' preferences regarding the design of the virtual classroom space. Participants were shown the three developed virtual environments and asked to indicate their preference for each (Figure 5). Participants were asked to evaluate the appropriateness of each scene using a 7-point Likert scale spanning from "absolutely inappropriate" to "absolutely appropriate." The third section of the questionnaire focused on questions related to teachers' training needs, and the final section focused on gathering data about real incidents that participants encountered during their career as teachers, serving as valuable input for future scenarios.

b. The participants

A total of 78 participants participated in the survey. Of these, 65.4% were female and 34.6% were male. Participants' ages ranged from 18 to over 60, with the largest age group being 30–39 years (43.6%). Teaching experience among participants varied from 1 to 33 years. Participants represented diverse teaching specialties, including primary education, literature, physics, mathematics, art, English language, economics, special education, and music. All participants were actively working as teachers across all educational levels, including primary, secondary, higher education, adult education, and the private education sector. Additionally, the majority of participants (78.2%) reported being inexperienced and unfamiliar with VR technology.

c. The results

A reliability check was conducted across all sections of the questionnaire, and the results revealed an alpha coefficient of 0.714, indicating the reliability of the 18 items. The results revealed that the participants considered the lifelike virtual classroom to be inappropriate for training, with 65.4% rating it as absolutely or slightly inappropriate. Additionally, 23% of the participants expressed neutrality, and only 11.6% rated it as slightly appropriate to absolutely appropriate.

In contrast, the fictional virtual classroom was considered more appropriate for hands-on training, with the majority of participants (58.9%) rating it as slightly to absolutely appropriate, and 33.3% expressing neutrality.

Furthermore, the fictional monumental virtual space received the most positive feedback, with participants (67.9%) rating it from slightly to absolutely appropriate, and 28.2% expressing neutrality. These results suggest a strong preference among teachers for more fictional virtual training environments.

Descriptive statistics indicated that participants favored fictional virtual spaces for their training. The Friedman Test revealed a statistically significant difference in the as-

sessment of the three figures, $\chi^2(2) = 74.858$, $p = 0.000$. Pairwise comparisons presented in Table 2 demonstrated statistically significant differences between the three virtual environments under evaluation. Figure 5 displays the mean scores for each virtual environment. The mean rank differences for the lifelike virtual classroom and the fictional monumental environment were −0.955, with a z-score of −5.965 and $p = 0.000$. For the lifelike virtual classroom and the fictional virtual classroom, the mean rank difference was −1.199, z = −7.486, and $p = 0.000$. Furthermore, for the fictional classroom environment and the fictional monumental environment, the mean rank difference was 0.244, z = 1.521, and $p = 0.385$.

Table 2. Pairwise comparisons related to the three virtual environments.

Comparison	Mean Rank Difference	z-Score	*p*-Value
Lifelike Virtual Classroom vs. Fictional Monumental Environment	−0.955	−5.965	0.000
Lifelike Virtual Classroom vs. Fictional Virtual Classroom	−1.199	−7.486	0.000
Fictional Virtual Classroom vs. Fictional Monumental Environment	0.244	1.521	0.385

The results imply a statistically significant difference between the lifelike virtual classroom and both fictional environments. Participants suggested that the lifelike virtual classroom was inappropriate for training and favored the fictional virtual spaces. This insight was significant for shaping the design of the final VR tool prototype (Figure 6). Additionally, it validated the preferences expressed by the target audience during the design phase, where they emphasized their preference for training in a more fictional environment. Although the monumental space was identified as the preferred virtual training environment, it was not integrated into the final VR tool prototype. This decision was influenced by input from school counsellors and psychologists, who highlighted the importance of ensuring that the training scenario closely resembles a classroom. The monumental space lacked familiarity and connection with the educational context. Hence, to balance the preferences of the teachers and the advice of the education professionals, the fictional classroom was selected for the final VR prototype. The fictional classroom environment was not only highly preferred by teachers but also demonstrated significant immersion, as shown in the earlier part of the research.

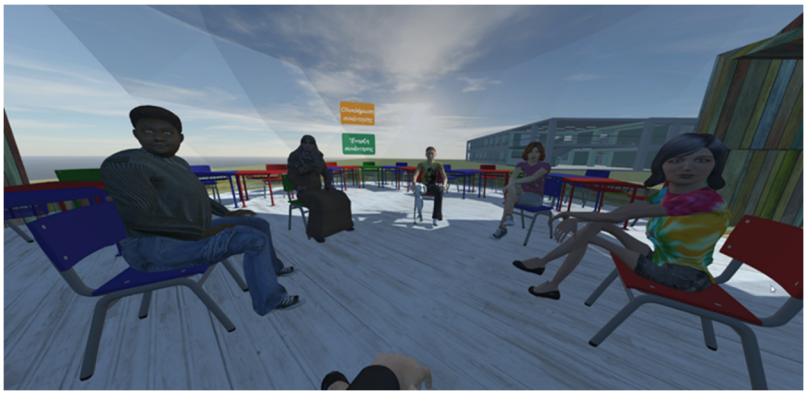


Figure 6. The fictional virtual classroom in the main scene of the VR prototype features five students along with start and stop buttons.

4. Discussion

This paper focused on the visual design of a novel VR-based training solution to address the lack of hands-on experiential training to foster the personal and professional development of teachers. The design of the virtual classroom environment emerged as a particular challenge, given the lack of research on the visual appeal of virtual classroom environments for VR-based teacher training. This fact highlights the broader challenge in VR development, emphasizing the lack of established design guidelines and best practices, particularly for educational applications [62,63]. The absence of a clear starting point compounds the complexity of creating effective and immersive VR applications, urging the need for further research and guidelines to guide designers and developers in this constantly evolving field.

Including teachers in the design process ensured that the tool aligned with the real needs and challenges they face within their classrooms, maximizing its effectiveness, added value, and user acceptance. The first step (described in Figure 1) was to identify teachers' needs, challenges, and requirements related to design aspects to define the appearance of the virtual classroom settings and key features that should be integrated. Subsequently, as a second step, consultation focus groups and interviews with the target audience took place to collect feedback on the preferred virtual classroom environment. Their valuable input was carefully considered in the design phase, where prototypes reflected a spectrum of opinions—in our case, the lifelike, fictional, and virtual classroom settings. Following the prototype development, the third step entailed conducting constant pilot testing and evaluation of the different virtual environments to gather feedback for modifications and adjustments. This included the use of mixed methods approaches (quantitative and qualitative assessments) to assess user experience, sense of presence, differences among the virtual environments, and the effectiveness of the VR experience and training. Analyzing feedback from testing led to the necessary modifications and adjustments to improve the design, scenario, and functionality of the virtual space to meet user preferences and needs. The prototype VR application was implemented to assess the tool's impact on empathy building, and teachers' feedback formed the basis for further modifications and new research directions. This iterative process ensured that user preferences and feedback shaped the final VR prototype, which was the final step of the process.

When designing a VR-based training tool, the virtual environment does not need to be a controversial classroom. Initially, the design approach leaned toward creating a virtual classroom space that replicated the lifelike classroom setting. Nevertheless, given the extensive daily hours that teachers spend in their classrooms, an alternative approach emerged that did not reflect teachers' actual classroom workspace. Co-designing the virtual classroom space with the target audience brought to light an alternative direction—creating a more fictional virtual training space while still evoking a sense of familiarity with a classroom setting. Consequently, through collaboration with the target audience, two different virtual spaces were designed: one reflecting a lifelike classroom and the other reflecting a fictional classroom space.

It was important to investigate whether this alternative fictional classroom environment influenced teachers' sense of presence and immersion differently when compared to the lifelike classroom space. The responses from the survey revealed similar levels of presence in both virtual environments, yet there were indications that the fictional classroom space might activate more cognitive processes in the participants. Additionally, contrary to the initial hypothesis that a lifelike environment would engage participants more effectively, the results revealed that the imaginary virtual space actually led to a stronger sense of immersion. The findings suggest that the imaginary environment, with its novel and creatively designed elements, provided a more captivating experience for

users. The results derived through this process are in line with the results derived from the analysis of EEG data [59]. The EEG data indicated that in both VR environments, the participants demonstrated alpha state synchronization—an indicator associated with the sense of presence. However, according to the results, the participants in the fictional classroom environment presented higher occipital lobe engagement, which reflects increased visual attention and processing and could explain the higher levels of immersion.

These results highlight the potential of fictional design to enhance user experience in VR-based teacher training applications, suggesting that lifelike, traditional, and familiar classroom settings might not always be the most effective choice. Stepping away from conventional classroom environments can enhance teachers' immersion and presence, offering a refreshing escape from the daily routine of training experiences. This fictional classroom space could not only enhance creativity and out-of-the-box thinking for teachers, but it could also serve as a mental break from the challenges of the real classroom. However, at the same time, teachers can be trained in real classroom challenges more creatively.

To further explore the results, a new survey was carried out, and a third virtual environment was created—a fictional monumental space. The results indicated a preference of teachers for the fictional monumental space, with the fictional classroom as their second choice. The lifelike classroom, on the other hand, was rated as an unsuitable training space. The findings confirm the previous results that non-traditional classroom environments may be more engaging and effective for teachers. Based on the results, the final VR training tool was developed, where training scenarios take place in the fictional classroom environment. Although the fictional monumental space scored higher, for the final design choice, input from secondary target audiences, such as counsellors, school psychologists, and other educational professionals, was taken into consideration, ensuring that the training tool also aligns with practical considerations, such as reflecting elements of a real classroom. The VR training prototype developed was implemented to assess the impact of VR-based training on empathy-building. While the results from the evaluation of the VR-based intervention are beyond the scope of this paper, it is worth noting that the training had a positive impact on empathy development. Additionally, the participants once more confirmed their preference for fictional classroom training environments over lifelike classrooms. Some participants, however, expressed the need for customization of the virtual training environment based on their needs, but this requires further research to understand its impact on user engagement and on the training outcomes.

An important takeaway from this research is that the design of VR-based teacher training environments must align with the design preferences of the primary target audience (in this case teachers), even when their preferences are not the most obvious or expected. However, at the same time, it is essential to keep a balance between fictional and lifelike elements in the training environment by integrating familiar classroom features, offering teachers a refreshing and engaging training experience that makes them feel comfortable. Involving teachers as co-designers during the design and development of the VR prototype was crucial, as the final deliverable reflects their need for a fictional virtual training space aligned with their real-life classroom scenarios. By integrating features that represent the challenges they face in their classrooms, the virtual environment provides a creative yet relevant context for training. Teachers' active engagement and feedback brought their diverse perspectives to this research and contributed to future modifications of the tool, such as the customization option.

One of the challenges of this research is the relatively small sample size, which limits the generalizability of the results. However, despite this limitation, the findings open new directions for designers regarding the design of VR-based training tools. The insights gained highlight the potential of developing more fictional, customizable, and user-centered

virtual training environments with practical relevance, rather than focusing only on developing virtual spaces that replicate the physical world identically. By expanding on these findings with larger sample sizes, more balanced VR-based training environments that incorporate fictional elements but are aligned with lifelike challenges may create highly engaging and effective experiences for users. Additionally, further research in other contexts could provide evidence on the integration of fictional elements when designing VR environments that detach users from their daily routines while at the same time providing highly immersive experiences and having high training value for end-users.

Implementing VR in teacher training presents unique possibilities but also notable challenges. Teachers' unfamiliarity with VR technology may affect their engagement and comfort levels with the VR training environment, influencing their feedback on the usability and impact of the training tool. Additionally, the lack of established frameworks for the design of VR-based training applications for teacher education makes it difficult to evaluate and compare VR applications across studies. Future research could contribute to the development and testing of frameworks for VR-based training tools for teachers, offering structured guidance to enhance the effectiveness of VR training tools for educators.

5. Conclusions

This paper presented insights gained during the design journey of a VR application for teacher training, highlighting that creativity and out-of-the-box thinking are essential when designing VR-based training applications, as the expected is not always the proper direction. The design process adopted a co-creative approach, involving teachers at every stage of the design and development process. Co-designing allowed for a deeper understanding of the needs and challenges encountered by teachers and enabled them to contribute to the conceptualization, prototyping, and development of the VR classroom environment. Participants' feedback not only guided improvements but also posed new research questions for future research in the field. Additionally, teachers' input was collected and categorized to be used in the future for the development of new scenarios based on real-life incidents and technical updates in the application.

Building on the insights gained from this project, the researchers initiated a project entitled VRTEACHER to address the evolving challenges in teacher training in the context of the COVID-19 era. The project aimed to address the lack of hands-on practical training experiences for teachers by providing them with a realistic and immersive training tool that would enable them to experience and navigate virtual classrooms firsthand [64]. By immersing teachers in realistic virtual classroom scenarios, the project aimed to enhance their understanding, empathy, and preparedness to tackle various educational challenges, including remote learning, psychological distress, phobias, cultural diversity, and issues related to inclusion and accessibility. Furthermore, the researchers aim to use the proposed systematic approach for the development of VR-based training tools in other fields such as entrepreneurship and sustainability and provide a novel design and development framework for VR-based training tools to be used in future initiatives.

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