On the Potential of Using Virtual Reality for Teacher Education

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Abstract. Virtual reality technology has the potential to be used in teacher training as it can provide innovative virtual teaching environments, offering teachers the ability to gain in-training feedback and knowledge that can be transferred and applied to real-life situations. As part of an initial investigation into the applicability of using VR for teacher training, two experiments were conducted. The first experiment had to do with teachers' understanding and detection of students' possible disorders such as vision disorders. The second experiment had to do the ability of teachers to identify and deal with bullying-related activities among students. The results indicated that through a VR-based role-changing mechanism teachers could enter students' position and understand their problems, while they experienced incidents that were like real-life incidents making the application a valuable training tool. The overall results of the preliminary investigations in combination with the findings of a related survey, highlight the potential of using VR for implementing real-life tools for teacher professional training. Building on the results of the preliminary experiments, a new application is currently under development aiming to address the lack of practice in teacher training and provide to young but also experienced teachers a VR-based school environment that represents real-life situations and will allow them to be trained, experiment, test their skills, make mistakes and learn from them but without the risk of harming real students.

Keywords: Virtual reality · Virtual classroom · Teacher preparation · Teacher training · Head Mounted Display (HMD)

1   Introduction

The integration of technology in the educational process gave new perspectives on teaching and learning aiming to equip students with the appropriate skills that will enable them to meet the demands and challenges of the modern world. In such a dynamically evolving environment, there is a necessity for educational systems to adjust to radical changes to meet the ever-increasing challenges of the 21st century. The transformation and modernization of the educational systems has become one of the strategic objectives of the European Union-EU [1], as the adjustment to the challenges will ensure that all European citizens will be equipped with the necessary competencies and skills required for sustainability and success in the labour market. Moreover, investment in education

is considered to be the solution to the current financial economic crisis, as it will promote economic growth, competitiveness, job-creation, productivity and prosperity.

However, the current educational systems were not designed to teach today's generation of students, the so-called 'Digital Natives', who have access to technology since their birth [2]. Thus, education must confront the problem of teachers, the so-called 'Digital Immigrants', who were not born into the digital world and are struggling to keep up with technology and adapt to the new circumstances and teach a generation that speaks the language of the digital world [2]. Unfortunately, teachers still believe that learners are the same as in the past and thus the traditional teaching methods can be effective. But todays' learners speak a different language and the traditional teaching and learning methods can no longer provoke their interest.

It is an undeniable fact that the transformation and modernization of the educational systems cannot be achieved without the contribution and active participation of teachers. Regardless the implementation of technology in education and the use of new and innovative teaching tools and practices, teachers remain the key wheel of education. Teachers are the strategic agents of educational change and with an enormous responsibility in the preparation of the future generations of active European citizens. In this new and challenging environment, teachers not only have to survive but they also have to respond with success to ever-changing class environments. As the classroom changed, the traditional role of teachers inevitably changed and they became students' partners, co-researchers, co-travelers and mentors between students and a rapidly changing world [3].

From this standpoint, teachers must renew their skills and competencies in order to confront the challenges and specificities of the framework within which they must act. It is essential that teacher education programs prepare candidate teachers with the necessary skills in order to respond with adequacy and effectiveness to the increased requirements of their profession. Teachers must have a deep understanding of their domain, use teaching strategies that will engage their students and build on their prior knowledge fostering their understanding. Additionally, teachers must find a new way to communicate with their students and new teaching methods to attract their interest and guide them in the acquisition of knowledge. Investing in teachers is essential to enhance their professionalism and provide education of good quality.

Nevertheless, research indicates that teacher education programs do not adequately prepare candidate teachers with the necessary knowledge, skills and competencies and as a result when teacher graduates enter the profession, they lack the knowledge for effective teaching [4]. Another concern is that little emphasis has been placed on 'learning to do' deriving learners from the opportunity to acquire through work experience the skills that will allow them to deal with difficult and unforeseen situations that might arise and learn to work with others [5]. Unfortunately, teacher training within the university is theoretical and there is a lack of practice and collaboration between schools and teacher preparation programs deriving candidate teachers from important resources and mentoring [4, 6, 7]. Without doubt, the lack of practice and connection between school and universities derive candidate teachers from the ability to acquire knowledge through experience and mentoring from experienced teachers [6, 7].

Beyond a shadow of doubt, the role of the teacher had to be redefined towards a new direction in this new multicultural and global arena. Virtual environments can address

the need for practice in teacher preparation and can provide teachers (beginning and experienced) the feedback, the mentoring and the realistic view that they need [4].

The last few years, the use of virtual reality in the landscape of education has attracted the interest of the scientific community due to its potential educational effectiveness because of the high-fidelity simulation and representation of space they offer. Virtual reality (VR) learning is an ideal way to provide users a safe, controllable and flexible environment, allowing experimentation in real-life situations that in many cases cannot be accessed physically.

In the remainder of this paper the term Virtual Reality along with the use of VR in education is introduced followed by an analysis related the uses of virtual reality in education. In section four two experiments that were conducted are presented along with preliminary results followed by regarding description of the development of a novel application under development. Finally, some considerations, conclusions and plans for future work are presented.

2   Virtual Reality: Defining the Terms

The concept of virtual reality has been around for decades, although it became popular and drew much attention in the early 1990s. There is no consensus on the definition of virtual reality as it is a multidimensional concept with a variety of characteristics. Virtual Reality (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 or gloves fitted with sensors' [8]. For Lawson et al. [9], VR 'is a system which permits users to interact, move, look at, and be immersed in a 3D environment'. Moreover, VR is 'an absorbing, interactive, computer-mediated experience in which person perceives a synthetic (simulated) environment by means of special human-computer interface equipment. It interacts with simulated objects in that environment as if they were real' [10]. VR aims at making 'the user located in the three-dimensional data environment expressed by the computer, and travel in this environment by eyes, hands, ears or special three-dimensional device, to create a sense of being on the scene' [11].

The above definitions of VR point to several important characteristics related to the concept. First and foremost, VR aims to immerse or absorb the user in a more learner-centered and learner-controlled computer generated environment, leading to higher levels of engagement when compared to a traditional classroom setting [12]. The significance of virtual reality also lies in its ability to produce high levels of sense of presence allowing the users to feel like 'being there' [12, 13].

There are three key elements of VR known as the '3I' - Immersion, Interaction and Imagination [11, 14]. Immersion is one of the key elements of a virtual environment, as it refers to the sensation of being physically present in a non-physical world [8]. For Cheng [11], immersion or else called 'the sense on the scene, 'refers to the degree of reality that the user feels when he exists as hero in the virtual environment'. Deep engagement in the virtual environment causes lack of awareness of time and of the real

world, convincing players that the virtual environment is real and making them feel that they are there.

In order for virtual reality to provide an authentic real-life experience to the user it is necessary to respond to the users' actions [15]. Thus, another important element of VR environments for user's successful experience is interactivity. Interactivity takes place when the computer responds to users' input. Finally, the element of imagination stresses 'that the virtual reality technology possesses a wide imaginable space, which can widen the knowing scope of human beings, not only represent a truly existing environment, but also mentally construct a non-existing environment, even an impossible environment' [11].

Technology allowed the development of immersive virtual reality applications that can be applied in many fields. VR has been used as a tool for the treatment of agoraphobia with and without panic disorder, public speaking anxiety, social anxiety disorder, fear of flying, spider phobia, eating disorders, psychological stress, schizophrenia and autism [13]. Moreover, VR offers the users the opportunity to live the life of someone else getting an idea of what someone else's life might be like [16] or even how one's life at a different age might be like [17]. For example, researchers from BeAnotherLab developed an interactive virtual environment called 'The Machine to be Another' in order to address the relationship between identity and empathy [18]. 'The Machine to be Another' aimed to help the users understand the Self though understanding the Other's point of view [18].

VR can also be used in domains as automotive industry. Car design is an expensive and time-consuming process that requires several modifications and reviews before the product goes to production. Thus, VR environments can be used in the design and development phase in order to reduce the time and cost required while maximizing the quality of the product [9]. Furthermore, VR environments have been used for pedestrian safety training. Many pedestrians are killed or injured annually with most of them being children, as children have not yet developed the cognitive and perceptual processing skills in order to cross the streets with safety. VR can offer children a safe, fun but also realistic training environment for repeated practice minimizing the risk of potential injury [19].

3   Using Virtual Reality in Education: State-of-the Art

As Ke et al. [20] state 'teaching is a complex problem-solving task that requires weighing many variables and adaptively implementing principles of instruction, communication, and content representation in a highly situated context'. Lately, teaching practice in schools with real students is becoming more difficult to accomplish. Nonetheless, beginning teachers are expected to be of highly professional quality and practice. Technology might give the answer to the request for a strong training in teacher preparation, enabling pre-service but also in-service teachers to improve the quality of their learning and performance. Additionally, one of the most significant problems of the teaching profession is that many teachers are leaving the profession during the first years. Thus, virtual

training environments may result in reducing the percentage of teachers that leave the profession, as after virtual training teachers may feel more confident and well equipped.

Virtual learning environments can be used for the development of effective future teachers that will be successful in the classroom. Virtual reality provides the users with realistic environments that allow real time active learning and the transfer of knowledge and skills from the virtual to the real context [20]. Moreover, constant training within the virtual environment will better prepare teachers and will ensure their survival in todays' digital and multicultural classrooms. However, despite the extensive use of virtual technology in fields such as medicine and military, in the field of teacher education its use is extremely limited.

The significance of using immersive environments in teacher training lies in the fact that the diversity in the classroom is growing and teachers must attend multicultural classrooms and bilingual students with different cultural and ethnic backgrounds but without intercultural experiences [21]. Dieker et al. [21], also suggest that the purpose of using a virtual training environment is to 'positively impact teacher recruitment, preparation, and retention in education', and provide teachers a safe environment where they can be trained with virtual students that is a 'more ethical approach to learning the art of teaching'. Another key point is that within the virtual environment teachers can make mistakes but without influencing learning of real students and they can repeat the experience to work on their mistakes and no matter how many times teachers may was to experiment, the virtual students have no memory of the process.

Virtual classroom environments aim to provide an innovative training tool that can be used for constant professional development and update of teachers' skills so that teachers can remain productive [22]. Furthermore, the use of virtual environments will allow teachers to take control of their own learning, monitor their progress and thus learn more. Equally important is that the virtual environment will provide immediate feedback and data that in an actual classroom would be difficulty to identify [21].

The last few years some attempts have been made in the preparation of teachers via virtual training environments. Dieker et al. [21], propose the use of virtual environments in teacher training. A prototype virtual environment was developed called STAR simulator and aimed to identify and recruit the best teachers, and train them. The goal of the realistic virtual environment was to provide physical, emotional and social interaction like this that teachers face in reality. The objective of the virtual environment was to create a realistic urban middle school to provide rich experiences to the participating teachers through interactions with the virtual students and collect the data for analysis.

Overall, the results of the research related to the STAR classroom revealed that it is possible to develop a virtual environment that can provide teachers with realistic and compelling experiences as if they were in a real classroom with real students. Nevertheless, further research and evaluation is required for safer results. Based on the results, teachers found the virtual classroom environment realistic. However, teachers proposed several modifications for the future including the presence of more students in the classroom, ability to see students' work during the tasks, movement from the students (sitting up from the desk or movements around the room or even possibility to leave the room). Additionally, beginning teachers reported that such a simulator can be used to help them in behavior management. Finally, the participants found the STAR simulator a friendly

and fun environment and expressed the desire to get trained again, experimenting with their approach.

TeachMe is another virtual environment that was developed for teacher training. The prototype focused on behavior and classroom management aspects and the goal was to train beginning teachers in mathematics, science and special education before entering in the classroom for the first time [23]. The results of the experiment with TeachMe virtual environment indicate the potential in training teachers in behavior management issues. Andreasen and Haciomeroglu [23], state that such a simulated environment can help teachers gain in depth knowledge of their domain and assist the development of behavior management strategies.

Ke et al. [20], also investigated the potential use of virtual reality in the training of teaching assistants. A virtual classroom environment was developed via an open-source platform called OpenSimulator, and the virtual students was a mixture of students controlled by scripts and students controlled by peer trainees. Kinect was also used enabling the participants to project and embody their real-time body movements and gestures onto their avatars in the virtual world. The results of the experiments indicated the potential use of virtual environment in teacher training. The use of Kinect that allowed the users to project and embody their real-time body movements and gestures, not only reinforced their sense of presence but there are also indications that it affected positively the pedagogical knowledge of the trainees. However, further research is a necessity for safer results.

The above studies suggest a potential for using virtual reality environments for active teacher training. Research so far has indicated that virtual environments can engage the users while reinforcing the sense of presence resulting in the acquisition of deeper knowledge and skills. Nevertheless, research is still at its infancy and further research is required in order to examine how virtual environment can be implemented effectively in teacher training maximizing teachers' competencies.

4   Preliminary Experimental Evaluation

The last few years the technological advancements changed dramatically the traditional classroom and the role of the teacher. From unique source of knowledge, teachers became guides to help the students conquer and construct their own knowledge. Moreover, the implementation of technology in education changed dramatically the traditional classroom that became digitalized and dynamic. Despite the changes in education teachers remain the main actors of every educational system and thus, the professional development of teachers became a priority for the European Union.

Unfortunately, initial teacher education does not adequately prepare pre-service teachers and thus beginning teachers entering the profession encounter several problems and feel unprepared to deal with the complexity of today's classroom. Moreover, most beginning teachers lack practical skills, as there is a lack of connection between Universities and schools deriving them from the mentoring and support that they need from experienced teachers.

As part of an initial investigation into the applicability of using VR for teacher training, two experiments were conducted [24, 25]. The first experiment had to do with teachers' understanding and detection of students' possible disorders such as vision disorders. More specifically, myopia disorder had been chosen as the students' disorder within the scenario. Students with myopia often feel embarrassed to wear glasses in the classroom as they are being targeted, bullied and teased by other classmates. As a result, teachers might be unaware of student's situation and believe that students' limited participation during the lesson is due to lack of interest rather than due to health reasons. During the VR application teacher-users could see through the eyes of a visually impaired avatar in order to raise their awareness towards students' eye conditions and help them identify students with myopia symptoms (see Figs. 1 and 2).

Fig. 1. The virtual environment showing clear and blur vision
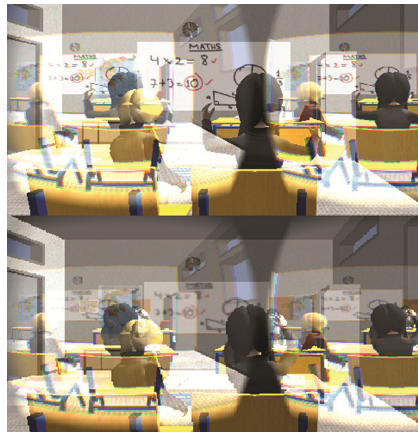

Fig. 2. The virtual environment showing vision problems of the student as seen through an Oculus Rift

Both applications were developed as a first-person 3D virtual environment using the 'Unity3D' game engine. The avatars used in the virtual environments were created with

the Maya Autodesk Character Generator student version and were imported in the Unity3D game engine. One aspect that had to be considered for the design of the virtual classroom was that it had to be realistic and like a real classroom to maximize the sense of presence. Therefore, photographs were taken from a real classroom and then the models for the classroom were designed in Maya. To create a realistic immersive experience for the teachers, Head Mounted Displays (HMD) and specifically Oculus Rift and headphones were used (see Fig. 3). Furthermore, to achieve higher level of realism in avatar movements, motion capture techniques that involved the use of a motion tracking suit in conjunction with multiple infrared cameras, were used to record human movements that were used to animate the avatars.

Fig. 3. Participants during the use of the virtual environment

In both experiments for the evaluation of the virtual environments two questionnaires consisted of closed-ended five-point Likert scale questions were developed. The first questionnaire aimed to collect demographic data and general information and was completed before the experiment. The second questionnaire was completed after the use of the virtual environment and aimed to collect data relative to participants' experience in the VR environment and the usefulness of the VR application as a training tool for teachers. Before taking part in the experiments all volunteers had to read and sign the consent document that provided general information about the research. Then participants had to test the virtual environment and at the end of the experiment they had to complete the second questionnaire.

The quantitative results indicated that participants found the virtual environment of the classroom a realistic representation of the real classroom setting. Thus, there were high levels of immersion and the participants felt like being in a real classroom setting and the use of an HMD and headphones also helped in participants' immersion. Moreover, all the participants experienced a sense of presence, like being in a real classroom. Teachers participated in the experiment reported that they could enter students' position and understand their disorder something that will be beneficial for their future teaching practice. Furthermore, participants reported that virtual environments like the one they experienced could be a useful tool for teachers in order to understand students' problems. Equally important is that all participants stated that they were problematized because they had never had the chance to enter the students' position before and through the current application they experienced their students' viewpoint. Moreover, many of the participants admitted that it was highly possible that in some cases they had misjudged real-life students due to their inability to consider the possibility that such students had a vision disorder.

The second experiment had to do the ability of teachers to identify and deal with bullying-related activities among students. As the aim of our application is to address

the lack of practice in teacher training in school bullying, there was an effort to record real life incidents that could be incorporated in the scenario of the application. For this reason, a focus group interview took place with experienced teachers and school counselors in order to obtain information about real life bullying incidents. The participants provided multiple examples of school bullying incidents and they suggested that the most important aspect for new teachers is to be able to differentiate bullying incidents from simple teasing incidents among the students. As bullying is a repetitive action, teachers must observe carefully the behaviors and those students involved to identify bullying activities. Based on the feedback received by experienced teachers and school counselors the following scenario was drafted to fulfill the needs of required application.

Within the VR application the teacher-user experienced different types of in-class and outdoors student behavior incidents related to bullying. For each of the incidents the user can select one of a series of choices related to the appropriate actions that need to be enforced for each incident. The first incident was teasing and the second and third incidents constitute bullying as it is a repetitive action from the victimizer to the same target person. Thus, user-teachers must observe carefully the behaviors and the students involved in order to recognize bullying.

The quantitative results revealed that the behavior problems that pre-service teachers experienced were like their real-life incidents making the application a valuable training tool for identifying bulling, and taking the correct actions depending on the nature of the incident. It was also evident that most the participants consider bullying a serious problem within the school environment. What is interesting to be noted is the fact that in service and experienced teachers argued that training via a virtual environment cannot contribute significantly in the development of their skills as they already possess the skills to confront bullying due to their everyday experience. They proposed the use of the application for the training of pre-service teachers who lack the experience to identify bullying. However, most of the teachers failed to recognize and distinguish the teasing incident from the bullying incidents.

The overall results of our preliminary investigation proved that the use of virtual reality in teacher preparation has considerable potential. Moreover, the development of such a tool could be also an innovative and valuable life-long learning tool.

5   Developing an Integrated VR-Based Teacher Training Tool

Building on the results of the preliminary experiments, a new application is currently under development aiming to addresses the lack of practice in teacher education and the need for the professional development of teachers. In addition, a survey that aims to register teacher needs and opinions regarding the use of VR in their professional development was carried out. Preliminary results of the research indicate that there is a lack of practice in teacher training and a lack of experience among teachers related to the use of virtual reality. Teachers reported the need of further training in teaching students with special learning needs, in confronting students with disorders such as vision, hearing and speech disorders, in behavior management and in body language. Additionally, according to the results it is difficult for teachers to deal with students who show behavioral disorders (including

violence, aggression), health disorders, learning disabilities and Attention Deficit Hyper-activity Disorder (ADHD). Furthermore, a significant number of participants report that teachers need additional training for all the above-mentioned issues but not in theory, but in practice within a virtual classroom environment.

The proposed application aims to address the lack of practice in teacher training and provide new but also experienced teachers a mentoring, support and life-long learning tool that they need for their professional development. A virtual reality school environment representing real-life situations will allow teachers to be trained, experiment on their skills, make mistakes and learn from them but without the risk of harming a real student. The logic for the proposed application is outlined in Fig. 4:
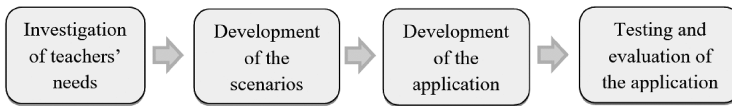
Fig. 4. The logic of the application

Based on the survey and the results concerning teachers' real needs, different scenarios for the application will be developed. The logic for the development of the scenario is presented in Fig. 5.
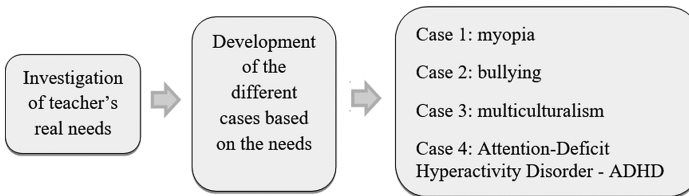

Fig. 5. The logic for the development of different scenarios

The new application is being developed using Unity software. From a hardware point of view, the set-up makes use of an Oculus Rift VR headset for a more immersive experience. Moreover, Maya is used for the development of the school and classroom models, while the models of the virtual students are designed with Maya Autodesk Character Generator student.

One important aspect that had to be considered for the design of the virtual school and classroom was that it had to be realistic and similar to real classrooms, in order to create the users a strong sense of presence that is the illusion of being an active part of the computer-generated virtual environment. For this reason, the model of the virtual classroom was designed based on photographs that were taken from real classrooms and on the specifications of the company 'Buildings Infrastructures' (http://www.ktyp.gr/en/) that is responsible for constructing Greek public buildings including schools (see Fig. 6 below). The virtual classroom models and the virtual students can be seen in Fig. 7 below.

Fig. 6. An image of the real classroom environment (left) and an image of a students' desk according to Buildings Infrastructures Company (right)

Fig. 7. The simulated classroom environment created with Maya without (left) and with students (right)

6   Conclusions

The introduction of educational technology in the classroom has a profound impact upon the role of the teacher and of the student. Teachers are no longer the source of information but they aim to facilitate students to conquer knowledge and develop their skills. Nevertheless, teachers' role remains significant since his/her educational techniques will provide students the experiences they need in order to gain new knowledge affecting their learning outcomes.

Teachers need to improve their skills through constant practice. However, there is limited training and lack of motivation. The recent technological developments have made it feasible to develop 3D VR environments for teaching, learning, and training. Integrating virtual reality environments supplementary to traditional university education will enhance teacher's motivation and professional development on classroom and behavior management aspects.

There are strong indications in preliminary research results [24, 25] that the use of VR environments in teacher training can improve teachers' skills and knowledge. Moreover, the results from the investigation of teachers' needs revealed a great interest from teachers for practical training within a safe virtual classroom environment. As virtual environments represent real-life situations, they create a strong sense of presence to the participants making them feel as if they are in an actual classroom. The sense of presence absorbs the participants to the virtual environments allowing them to focus on the

scenarios reinforcing their skills. VR holds a promise in the domain of teacher training, nevertheless further research is needed in order to investigate and evaluate the impact of those environments in the development of teachers.

In the future, we plan to build on our early promising results and further develop the VR application tool and enrich it with scenarios that correspond to teachers' real needs. The results of the survey regarding the investigation of teachers' needs are still under analysis. Based on the results, interviews and focus groups with experienced teachers and counselors will take place in order to gain a deep understanding of teachers' problems, so as to develop scenarios that best fit their needs. Then, we will perform an extended evaluation of the application, that will provide feedback for changes in the VR environment and provide information relating to the impact of the VR environment in the development of teachers' knowledge and skills. Such actions will contribute towards the development of an innovative and useful tool for teacher training that will allow teachers to gain practical experience within a safe but also challenging environment.

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