Assessing the emotional impact of Virtual Reality-based teacher training

Abstract

This paper proposes the use of a Virtual Reality (VR) based approach to improve teacher education and life-long professional development. Through constant training in real-life based situations but within a safe three-dimensional virtual school environment, teachers are given the opportunity to experience and learn how to react to different types of incidents that may take place in a school environment. The current paper presents the design cycle that was followed for the implementation of the VR teacher training system. The effectiveness of the proposed approach is demonstrated with a case study that aimed to promote teachers' understanding of student's problematic situations related to substance use. As part of the experimental investigation the impact of the VR system on participants' emotions and mood states is evaluated through EEG measurements, heart rate recordings and self-reported data. Results indicate significant changes to participant's negative emotional and mood states, suggesting that the scenario and the VR experience had a strong impact on them.

Keywords: Virtual Reality, teacher training, emotions, moods, teacher competencies, substance use

1. Introduction

The last few years the educational systems throughout the world have experienced radical changes and enormous challenges that formed the basis for a necessary change, transformation and modernization. Together with the changes within the educational systems, the traditional role of teachers inevitably changed and investment in their professional development has become a necessity and a top priority in the strategic agenda of the European Union (EU).

In line with EU objectives, this paper aims to propose the professional development of teachers using a contemporary Virtual Reality (VR) based approach. There is a lack of research in the use of VR in teacher education and thus this research aims to fill this gap. By taking advantage of VR technology, it is possible to provide teachers a safe environment, within which they can be trained and transfer the knowledge gained within the VR environment in their real classroom. The proposed VR framework aims to support teachers' continuous professional development through systematic individualized learning improving the quality of teacher education and practice. Moreover, this paper presents the proposed VR approach through a five-phase methodological framework that was based on the ADDIE model, which includes the pedagogical framework, the development of the scenarios followed by the development of the VR application and the evaluation of the impact of the proposed approach.

The proposed VR based approach aims to provide an innovative framework to teacher education and the related training methodology. In the long-term, the proposed VR system aims to form a new paradigm of teacher training, an alternative safe method that will allow user-teachers to learn through trial and error techniques that reflect real-life situations within a three-dimensional school space and without the risk of harming real students. To the best of our knowledge this is one of the first systematic attempts to use a VR based methodology to address real teachers' needs. The development of the VR application is linked to both strong theoretical foundations in education derived from the literature but also from real teachers' problems and requirements derived from an extensive literature analysis, survey and interviews with

experts including teachers, school counselors and psychologists. The VR tool addresses specific teachers' competences as outcome, after an extensive documentation of existing Teachers' Competence Models (Darling-Hammond & Bransford, 2005; European Commission, 2011; McDiarmid & Clevenger-Bright, 2008) and significant guidance by experts who pointed specific competencies of primary importance to teachers.

2. Literature review

2.1. VR in teacher education: addressing the problems and challenges

An extensive literature review research revealed as one of the most common and significant problems in teacher education the lack of practice in the school setting. Most universities but also lifelong learning programs for teachers rely on theoretical teaching that lacks strong communication and collaboration channels with the school environment (Hagger & McIntyre, 2006). Thus, those programs do not provide practicum that would give teachers the opportunity to learn on the job through the experience of their colleagues, instead of using trial and error techniques in their own classroom that may affect negatively the cognitive, social and psychological development of the students (Darling-Hammond, 2006). Hence, there is a theory-practice gap that needs to be addressed that will lead to high-quality and well-trained teachers leading to high-quality education.

This gap between theory and practice can be bridged by experiential learning and VR could offer an effective way for this type of training by providing engaging and immersive experiences that reflect real world classroom situations (Caena, 2014). The last few years, the use of virtual reality environments in education to foster learning has attracted the interest of the scientific community, nevertheless, its use remains extremely limited especially in teacher education (Freina & Ott, 2015). The significance of using VR in teacher education lies in the fact that VR mimics real-world situations allowing the users to experience realistic learning experiences that are transferable to the real world. This fact makes VR learning environment a suitable tool that can be used for the professional development of teachers. Furthermore, the development of 'extreme' scenarios can allow teachers to be trained via simulated stressful conditions that would be impossible to simulate in a real classroom setting.

Research results so far indicate that VR is a promising training method for teacher education, which entails a large educational potential (Manouchou et al., 2016; Stavroulia et al., 2016). A key advantage of VR-based teacher training is the ability for experimentation within the virtual environment where teachers can make mistakes and learn from them but without influencing real students. By the same token, 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. Furthermore, the use of virtual environments will allow teachers to take control of their own learning and monitor their progress.

2.2. Emotions and VREs

Over the years, emotions have caught the interest of the scientific community. There is a need to investigate emotional experiences in Virtual Reality Environments (VREs) as there is a lack of research regarding user's emotional experiences (Felnhofer et al., 2015). The question that arises is why to investigate emotional experiences in VREs, which derives from the fact that emotions are involved in the

way we understand the natural world (Morie et al., 2005). Thus, as VREs can represent real-life situations, emotions have an integral part to play during the experience of the users in VREs. There is a lack of research regarding the assessment of emotional experiences of users within VREs as only few emotions have been investigated so far including relaxation, joy, sadness, anxiety, anger and boredom (Felnhofer et al., 2015). Anxiety is one emotion that has been address in many researches in the context of using VR for mental health problems and psychological treatment (Bouchard & Labonté-Chartrand, 2010). Thus, as the goal of the proposed VR system is to train teachers, their emotional state within the VRE during their training cannot be ignored.

There are several methods for the recognition of emotions in VR that include skin conductance and heart rate variability (HRV) in order to capture the responses of autonomic nervous system (Baumgartner et al., 2006; Kim et al., 2014). Moreover, electrodermal activity (EDA) has recently been tested as a reflection of the sympathetic activation of the autonomic nervous system (Felnhofer et al., 2015). EEG has also been used in order to capture the brain signal and its possible alterations as well as self-reports (Menezes et al., 2017; Rodríguez et al., 2015). For the purpose of the current research a multimodal approach was used, combining HRV, EEG, self-reports and head movement detection in order to be able to determine the emotional state of the user. The use of this multimodal approach was adopted in order to achieve higher reliability of emotion recognition.

3. Methodology

3.1. Research question and approach

The main research question that constitute the fundamental core of this research whether *a virtual reality-based learning paradigm more effective for the professional development of teachers*.

To answer the research question, a systematic approach including five phases was formulated based on ADDIE model traditionally used by instructional designers and training developers (Molenda, 2003). The ADDIE model was used as a process for the development of the VR training system. The five phases - Analysis, Design, Development, Implementation and Evaluation- represent a dynamic, flexible guideline for building effective training and performance support tools. Those five phases constitute a set of steps with a specific outcome that work together to enhance the overall outcome of the proposed VR-based approach. A description of the actions taking place in each phase is presented below.

3.2. ADDIE model for the development of the VR system

Phase 1 – Analysis and investigation of teacher's needs

Apart from an extensive literature review research, a survey was conducted in order to register teacher's real training needs (Stavroulia et al., 2017). The results of the survey provided critical information regarding teachers' real needs and this identification was taken into consideration for the development of the scenarios. Moreover, a focus group interview with in-service high-school teachers took place in order to reinforce the identification of the most important required aspects of teacher education. The results indicate the lack of practice in teacher education and the significance of implementing practice and on the job training within the university studies. Teachers reported that their training is mostly theoretical while

it lacks practice, mentoring and counselling. Regarding the most important training needs, teachers reported the need of training related to dealing with students with special learning needs, students with disorders (vision, hearing and speech disorders), behavior management issues, classroom diversity, individualized learning and classroom management.

Phase 2: Designing the competency framework for the proposed Virtual Reality-based investigation

The term teacher competencies refer to the 'teacher professionalism', to 'the multi-faceted roles of the teacher on multiple levels of the individual, of the school, of the local community and of professional networks' (European Commission, 2011:7). There are several recent approaches regarding teacher competencies and several models have been developed (Darling-Hammond & Bransford, 2005; European Commission, 2011; McDiarmid & Clevenger-Bright, 2008). Despite the differences among the various models, there are several set of competencies that are common including pedagogical content knowledge, issues of inclusion and diversity, use of technologies, reflection, research and collaboration skills and adaptability. Although the models that exist have identified the most significant competencies and skills for teachers it is impossible to address them all within the framework of the current research. Therefore, a specific selection had to be made based on the needs of the current research. A competency framework has been developed to describe the professional standards that the proposed VR system aims to strengthen ensuring optimum teachers' professional development. The proposed framework of competencies includes two key competencies that are: empathy (Christofi & Michael-Grigoriou, 2017) and reflection (Hammerness et al. 2005).

Empathy: Empathy is considered a skill of paramount importance for teachers, as it can foster the establishment of strong communication channels with the students promoting the development of a good classroom climate and student's satisfaction and involvement in the educational process (McAllister & Irvine, 2012). The cultivation of empathy skills is the only way for teachers to really understand their students, embrace their problems and take the necessary course of action for their well-being. However, despite the significance of empathy skills, most teacher education competence models do not include empathy as a key competence. An extended literature review revealed that empathy is included among key competence only to a model developed by the National Institute of Education (NIE) (2009) in Singapore. This gap regarding empathy to European competence models in conjunction with the indications by the interviewed experts formed the basis for addressing the cultivation of empathy skills to the current research.

Reflection: The development of critical reflection skills is essential for teachers (Hammerness et al. 2005). Through reflection teachers have the ability to evaluate their teaching practice and experience, re-examine and criticize it, aiming to make the necessary changes for self-improvement and improvement of the quality of their work. Thus, the ability to reflect is considered an integral part of teacher professionalization and one of the basic standards that teacher candidates must develop in order to achieve self-development (Lai & Calandra, 2007). Unfortunately, research results, indicate that teachers do not possess the ability to reflect even after receiving relevant education and as a result they faced difficulties in critically reflect on their teaching practices. Thus, it is essential to address the cultivation of reflective skills via VR.

Phase 3: Designing the scenarios

The design of the scenarios was based on the previous phases and the directions provided by experts. Until now, different scenarios have been developed and tested related to student's vision disorders, bullying, multiculturalism and bullying use in the school environment (Manouchou et al., 2016; Stavroulia et al., 2016; Stavroulia et al., 2018).

For the purpose of the current paper a new scenario involving substance use will be analyzed. The scenario was inspired by a real school incident related to the use of substances given to a 12-year-old student by his classmates, in the form of pills and after threats (Kounnou, 2017). The substance that is portrayed in the scenario is cannabis (also mentioned as marijuana in the scenario) and it was chosen because according to the 2017 European Drug Report, cannabis was the most commonly used illicit substance in Europe and its use was concentrated among young adults aged 15-34 years (EMCDDA, 2017).

Substance use is not only a major societal concern, but also a serious problem within the school environment. Research results concerning drug use in schools, indicate cause for concern as there are many cases recorded, even in primary education. Thus, substance use in schools is a fact and a real problem and not a possibility and as such should be treated. However, this specific type of problem has always been a taboo subject and neglect has been an ongoing challenge as the school and the teachers are afraid to deal with it. It is essential that educational staff is in the position to realize that students dealing with drug use disorders are not the problem, but they are facing a problem. Additionally, it is of paramount importance that teachers are not only open to accept this type of student disorder that might occur in their school or classroom, but also be able to detect possible symptoms of students associated with such disorders (such as aggression towards teachers or classmates, indolence, sleepiness etc.), as their role is significant to the promotion of preventive actions and raising students' awareness. However, preventive actions by teachers are unclear and teacher training in issues concerning substance use in school is missing.

Phase 4: Development of the application

Following the different scenarios considered, dedicated VR applications were developed using the Unity3D© game engine. In order to create a realistic immersive experience for the participants, an Oculus Rift VR headset was used as a means of viewing the application (see figure 1 below). The 3D avatars (teachers and students) were created using the online software Autodesk® Character Generator.

Figure 1. The participants during the experiment wearing Oculus Rift

Phase 5: Implementation and evaluation

The evaluation stage aimed to evaluate the effectiveness of the VR application, providing the information regarding its impact in the professional development of teachers. The assessment of the effectiveness of the VR-based training and the data gathered provided significant insights regarding the impact of VR approach in teacher education leading to the development of a tool to support for the professional development of teachers and thus the quality of education. The results so far demonstrate strong potential in the use of VREs in teacher education. The experience within the VR system can raise teacher's awareness and understanding of student's problems including vision disorders (Stavroulia et al., 2016), bullying incidents (Manouchou et al., 2016) and multiculturalism (Stavroulia & Lanitis, 2018; Stavroulia et al., 2018; Baka et al., 2018). The next subsection presents the results of the experiment related to substance use in the school environment.

4. The experiment: substance use related scenario

4.1. The research question

The main research question that constitute the fundamental core of this particular experiment is the following:

Does the use of VR impact participant's emotional and mood states?

4.2. The scenario

The scenario that was designed takes place in the school outdoors space during break time. A female student (named Anna), the so-called scene observer, is watching her classmate (Nikos), who is sitting on a bench, having done substance use and is experiencing the so-called bad trip[1] (Hartney & Gans, 2017). Anna asks another classmate (Kostas) for explanations and he admits that Nikos used substances and at the same time Kostas tries to persuade Anna to smoke a cannabis cigarette. Anna refuses but because of fear she remains indifferent when finally, the teacher approaches asking questions about the student drug user. The user-teachers were given the opportunity to view the experience from three different perspectives: teacher perspective (see figure 2 top), student-drug user perspective (see figure 2 middle) and student scene observer perspective (see figure 2 bottom).

[1] All hallucinogenic, psychedelic drugs including others like marijuana and cocaine can produce intense and distressing effects like frightening hallucinations and delusions.

Figure 2. Experiencing the incident through teacher's eyes (top), experiencing the incident through the eyes of the student drug user (middle), experiencing the incident through the scene observer's eyes (bottom)

4.3. The Research Tools

A combination of methods was used for the current research. Two questionnaires were used pre and post the experiment, including closed-ended Likert-scale questions. The questionnaire consisted of questions regarding participant's demographic data, participant's empathy skills and participant's mood states. The empathy scale used was derived based on already existing and validated scales with many modifications so as to meet the needs of the current research. Adjustments to the empathy scale used were carried out in close collaboration with an expert psychologist on drug issues. The mood states scale was based on the Positive and Negative Affect Schedule (PANAS), which comprises of two mood scales, one measuring positive affect and the other measuring negative affect. Moreover, the fitness wristband fitbit charge 2 was used for the measurement of the participants' heart rate and the 14-channel wireless EEG EMOTIV EPOC+ for recording brain signals.

4.4. The Sample

A total number of 25 participants (n=25) took part in the experiment with 88% (n=22) coming from Cyprus, one participant from Greece, one from Serbia and one from Ukraine. Among the 25 participants 52% experienced within the VR the perspectives of the teacher and the students drug user and the 48% experienced the perspectives teachers and student Anna. 72% (n=18) were female and 28% (n=7) were male, mostly aged from 18 to 39 years old (84%). 64% of the participants were active teachers, while 36% of the participants were not currently working as teachers. According to the results 36% of the participants currently serve in secondary education, 36% do not serve as teachers, 24% serve in higher education and 4% in primary education. The participant's teaching specialty varies among fields including computer science (20%), multimedia and graphic arts (16%), mathematics (12%), literature (12%), foreign language (8%), primary school teacher, physical education (sports), sociology, speech pathology, web design. In relation to the participants' prior experience in using VR applications, the results indicate that most of the participants were not familiar with the use of virtual reality as 36% claimed to have never use VR in the past, 32% claimed to have 'a little' experience in the use of VR, 12% claimed to have 'moderate' experience, 12 claimed 'much' VR experience and 8% claimed to be 'very much' familiar with the use of VR.

4.5. The Procedure

Initially, the participants were given a consent form with the instructions regarding the experiment. Then, they had to complete the pre-questionnaire and after the completion of the questionnaire the necessary equipment (EMOTIV EPOC+, Oculus Rift and wristband to record the necessary data) was attached on the user (see figure 3).. The exposure of the participants in the virtual environment lasted approximately 5 minutes, depending on the pace with which they were advancing the dialogues of the two scenes. After the end of the experiment the participants was asked to complete the post-questionnaire.

Figure 3. Preparing the user for the experiment within the VR system

5. Results

5.1. Positive and Negative Affect Scale Results

Reliability analysis was conducted on the variables of the positive and negative affect scale for both the pre and post questionnaires. According to the results the overall alpha for the pre-test scale is 0.841>0.7 and the overall alpha for the post-test scale is 0.864>0.7 indicating high reliability of the variables. The results from the tests of normality (namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test) both in pre and post questionnaires, revealed that most of the items are below 0.05, therefore, the data significantly deviate from a normal distribution and non-parametric tests were used for the analysis.

A Wilcoxon test was used to understand whether there was a difference in participant's positive and negative mood states before and after the use of VR. The response continuum for each positive and negative mood state scale is a 6-point scale (not at all-low-a little-moderately-very-extremely) indicating the extent respondents agree or disagree with each mood state. For the problem above the null and alternative hypothesis were:

H^{null}: There will be no difference in the rankings of participants regarding their positive and negative mood states before and after the use of VR.

H^{alt}: There will be a difference in the rankings of participants regarding their positive and negative mood states before and after the use of VR.

A Wilcoxon signed ranks-test indicated a statistically significant change in many mood-states after the exposure to the VR environment (see Table 1). More specifically, the use of VR elicited a statistically significant change in participants' state of fear (Z=-3.51, p=0.000), as the mean score rating for the state afraid was M=5.52 (SD=1.05) before the use of VR and M=3.3 (SD=2.05) after. The results indicate a change in participants' mood state of interest (VR Z=-2.14, p=0.035). However, mean scores before (M=4.6, SD=1.19) and after the use of VR (Mdn=4.1, SD=1.53) do not indicate a significant difference. Participants also tended to be more active before the use of VR (M=4.3, SD=1.22), than after (M=3.6, SD=1.50), Z=-2.43, p=0.015.

Moreover, the results indicate a statistically significant difference in participants' state of being nervous before (M=4.6, SD=1.73) and after the use of VR (M=3.3, SD= 1.73), Z=-2.31, p=0.21. Moreover, the results indicate that the use of VR elicited a statistically significant change in participants' state of sadness, Z=-2.94, p=0.003 (before the use of VR M= 5.1, SD= 1.55 and after M=3.2, SD=1.96). A statistically significant change in participants' state upset, Z=-3.91, p=0.000 (before the use of VR M=5.6, SD= 0.91 and after M=3.0, SD=1.96) was also observed

A Wilcoxon signed-rank test indicated that participants experienced shame conditions before the experiment before (M=1.6, SD=1.11) but after the experiment their feeling of shame were decreased (M=3.0, SD=1.80), Z=-2.72, p=0.006. Additionally, there are indications for participants' fatigue after the use of the VR, since the mean score rating for the state sleepy was M=4.6 (SD=1.19) before the use of the VR and M=2.9 (SD=1.80) after the use of VR. Moreover, according to the results the participants were more downhearted after the use of VR, Z=-3.19, p=0.001. Indeed, the mean score rating for the state downhearted was M=5.1 (SD=1.12) before the use of the VR and M=3.7 (SD=1.89) after the use of VR.

A Wilcoxon signed-rank test showed that the use of VR did not elicit a statistically significant change in the states of inspiration (Z=-0.25, p=0.79), calm (Z =-0.83, p=0.41), confidence (Z=-1.22, p=0.22), tired (Z=-0.47, p=0.64), alert (Z=-0.09, p=0.92), relaxed (Z=-0.64, p=0.52), determined (Z=-1.40, p=0.16) and concentrating (Z=-1.89, p=0.59).

Table 1. Wilcoxon Sign-Rank Test indicating differences between pre and post test scores

Table 1 around here

In conclusion, the results indicate statistically significant differences between pre-test and post-test scores suggesting a significant change in mood-states after the exposure to the VR environment. Thus, the null hypothesis is rejected, and an alternative hypothesis is accepted in its place. More specifically, according to the results the VR experience elicited a statistically significant change in participant's negative mood states (see figure 4) and did not affected that much their positive emotions and mood states (see figure 5).

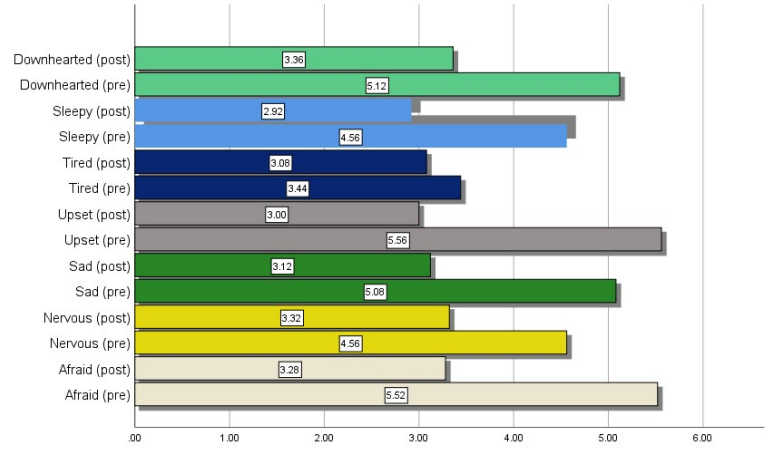

Figure 4. Participant's negative mood states before and after the use of VR that were mostly affected.

As shown in figure 4 above, participant's scores before the experiment lean towards the negative answer scales (6=Not at all, 5=Low, 4=A little), while after their experience within the virtual school world, their scores lean more towards a more central point of the scale (3= moderately).

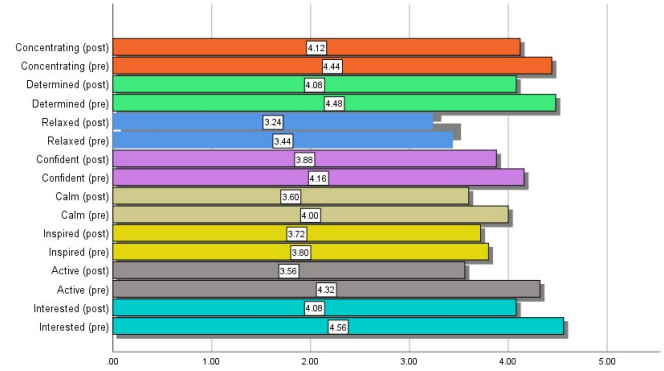

Figure 5. Participant's positive mood states before and after the use of VR

Figure 5 above, presents participant's scores related to their positive emotions and mood states before the experiment, leaning towards the positive answer scales (5=Very, 4=Moderately, 3=A little), while after their experience within the virtual school world, their scores were also affected but to lower levels that their negative emotions and mood states.

5.2. Heart rate and EEG signals

During the VR experience, the heart rate of the participants was measured. The results indicate a significant difference before and after the VR experience. HB1 represents the heart rate before the experiment (M=80.92 bpm, SD=10.59 bpm), while HB2 shows the heart rate after the experiment, (M=87.21 bpm, SD=10.97 bpm (see Fig. 6 below).

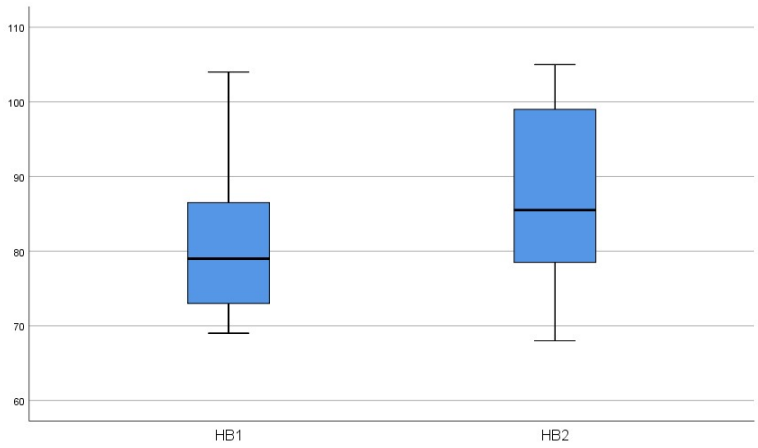

Figure 6. Participant's heart rate before and after the use of VR

The EEG signals were analyzed using the MATLAB toolbox EEGlab. The results indicate significant differences between the different perspectives (teacher-scene observer student-drug user student) regarding participants' brainwaves including the alpha and the beta rhythm. The alpha rhythm (8.0–12.5 Hz) is associated with relaxation, while the beta one (12.5 and 30 Hz) is associated with an alert cognitive state, decision making and critical thinking (Ramirez and Vamvakousis, 2012). According to the results, alpha waves were detected only when the scene was viewed from the perspective of the students (both scene-observer and drug user), while beta waves were detected in all perspectives (Christofi et al., 2018). Alpha brain activation generation reflects a calm psychological state, while beta activity reflects a more stressful situation (Seo and Lee, 2010). Since the first perspective observed by all participants was that of the teacher, it is possible that they initially experienced increased anxiety and stress that was decreased over time after the . familiarization with the virtual space, leading to an increase of the alpha activity during experiencing the perspective of the student. Moreover, beta activity in all perspectives reflects participants' attention and concentration but it could also reflect high levels of stress and anxiety.

The results obtained from Heart rate and EEG signal analysis are . . . . ..

6. Discussion

The present paper aimed to present the results of an investigation regarding the use of VR in teacher education. The proposed VR-based approach aims to present new opportunities for improving teacher training via using VR environments as part of teacher training methodology that will allow teachers to experience an entirely new side of training.

The purpose of the present study is to investigate whether the VR experience affected participants' emotions and mood states. The experimental investigation involved a scenario related to substance use in the school environment and the results of the experiment indicate that the use of the VR system elicited a statistically significant change in participant's negative mood states. Before the use of VR participants did not feel fear, nervousness, sadness, upset, ashamed or downhearted. However, after the use of VR, the results indicate a significant change of those states. Regarding the positive states no statistically significant changes were found after the use of VR. Thus, the scenario affected only the negative states that were absent before the experiment.

Further research is required to investigate participant's mood state changes with a different scenario, because it is possible that the context of the scenario with the drug use was indeed a taboo problem for the participants. Indeed, in-service and experienced teachers after the end of the experiment expressed strongly the opinion that it is not their responsibility to deal with students facing drug problems and their main concern must be to report the situation to the principal office to transfer the responsibilities. What is interesting is that those teachers reported to have encounter such an incident within their classroom but refused to act and preferred to ignore the student during the lesson. Thus, raising teachers' awareness and sensitizing them towards serious problematic conditions including substance use should become a priority in teacher training and VR can provide a training tool for this cause. Nevertheless, this investigation provided significant insights regarding the use of a VR based approach to teacher training in relation to substance use problems in the school setting and useful feedback was received for future changes in the application. Moreover, regarding the effects of cannabis on a user, further research is required, and interviews will be conducted with ex-cannabis users, so that the virtual effects depicted are as close to reality as possible. Additionally, after feedback from some of the teachers/participants, the drug incident would be more likely to take place in the bathrooms of the school and not in an open space like the school yard in the future version of the application.

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