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Pre-service Teachers' Acceptance and Intention to Use Virtual Reality Applications in their Teaching Practice. A Case Study

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Abstract. Virtual science labs are simulation software that allow students at any level of education and training to practice laboratory experiments at any time and in any place, giving the educational process a new dynamic. This study investigates the acceptance of immersive virtual reality applications by 4-year students attended an undergraduate university level program in Educational Sciences (Pre-service teachers), as well as their intention to use immersive virtual reality software in their educational practice. The pre-service teachers participated in a short duration course during which they worked with Onlabs, a free and open VR educational software, preparing an aqueous solution, handling the appropriate equipment in the immersive virtual environment. A pre-questionnaire and a post-questionnaire, based on Technology Acceptance Model (TAM) extensions related with virtual reality used as research tools. The findings of the study showed that the students' experience with the iVR application enhanced their Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment but not their values for Conditions of Facilitation. Their Intention to Use is marginally higher after the course.

Keywords: Immersive Virtual Reality, Pre-Service Teachers, Acceptance.

1 Introduction

Virtual Reality (VR) is a cutting-edge digital technology that has been used in recent years as an educational tool, since there is evidence that it enhances and supports an in-depth understanding of subject matter during the learning process. Many researchers agree that VR can successfully support laboratory-based courses at all levels of education [1, 2, 3, 4]. Both Desktop-based and Immersive Virtual reality (dVR and iVR) applications can have a significant positive impact on students' learning experience. According to literature, perceived learning outcomes provided empirical evidence for the ability of VR applications to support and enhance learning [5, 6]. As far as immersive VR, supporting fully immersive and embodied experiences can play an irreplaceable role in some learning situations [7, 8]. Various theoretical models assess the intention to use new technologies and technological applications, such as the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model (MM), the Theory of Planned Behavior (TPB), etc [9]. TAM is currently the most used user acceptance model for technology. It is a simple and easy to implement model. Numerous studies worldwide have extended TAM to fit different technologies and technological applications and tools, different application contexts and different users [9]. In this study, a combination and modification of TAM 2 and external factors, according to the research of Teo et al. [9] and the extension of TAM, according to the research of Sagnier et al. [10] was used.

This study aims to discuss pre-service teachers' acceptance f and intention to use iVR applications in their teaching practice before and after their participation in a short duration introductory course working with an immersive VR application.

2 Virtual Reality and User Acceptance

2.1 Virtual Reality Applications in Education

There are many ways to define iVR such as: VR is a complex multimedia system with a specific technological setup for high degree sensory immersion in a simulated world, or VR refers to a three-dimensional interactive simulation of an environment that users can immerse themselves in and interact with [10]. A wide variety of VR applications have been developed for entertainment, education, training, therapy, and rehabilitation [9]. Regardless of the definition, all agree that the innovative technology of full immersion VR offers users a unique experience where they experience a high degree of sense of presence [11] and control over their actions. The user wears the special mask and remote-control devices to immerse themselves in the simulated 3D space [12]. In Education and based on theories that both interest and emotion [13] are strong internal motivators associated with effective learning, it is expected that VR software, which is more enjoyable and creates more presence than learning through conventional means, will be a tool that students will choose for their learning.

Educational tools based on this technology can provide a highly interactive, self-contained, cost-effective, and safe learning experience that overcomes the limitations of laboratory facilities, technical support, and budgets available from educational institutions to upgrade and modernize laboratories [14, 15]. For example, Paxinou et al. [16] and [17] report and present evidence that this technology is a promising complementary tool to traditional teaching methods in laboratory biology courses. The authors reported that students who were trained in their laboratory exercises via a dVR application subsequently received statistically significantly higher scores on tests of conceptual understanding, were more confident in the knowledge they had constructed, and demonstrated greater proficiency in conducting experiments in the actual laboratory than their peers who followed more traditional teaching methods. Many advocates of VR software believe that this educational approach facilitates learning due to the human brain's ability to better perceive and more easily assimilate a three-dimensional (3D) representation of computer graphics than a simple text [18] even when referring to users who do not have digital skills [11]. According to Trundle & Bell [19], VR labs in science are useful educational tools as they highlight important information and remove unnecessary details, thus making the educational process more effective. Moreover, like all modern ICT educational applications, virtual applications have general characteristics that can support constructivist learning [20] and seem to be very effective in dynamically engaging students in the learning process [21]. Big companies, such as Apple, Google, Facebook, Microsoft, HTC, Magic Leap, Samsung, etc., have invested and continue to invest large amounts of money mainly in full immersion VR, designing modern and stylish VR headsets, creating spectacular virtual worlds. Although the expensive equipment that this software require does not allow their widespread diffusion in education, several studies have been conducted to investigate whether this educational approach could enhance effective learning [22] Given that the new generation of learners born and raised in the digital world, seek technological innovations, and demonstrate a proficiency in handling them [14] today's educators, rethink the teaching methodologies and the content of the educational material used in the educational process.

Many studies have focused on the usability of virtual reality, but few have used the Technology Acceptance Model [23] to study user acceptance of VR applications and other virtual environments [6].

2.2 Technology Acceptance Model (TAM)

Davis (1989) developed the Technology Acceptance Model (TAM) based on two psychosocial theories that try to explain and predict behavior: the *Theory of Reasoned Action* and the *Theory of Planned Behavior*. According to the TAM, the intention to use a specific technology is predicted by two user perceptions: the perceived usefulness and the perceived ease of use. During the years and wide-world, various extensions to the TAM have been proposed [9, 23, 24] including factors from *related models* (e.g., subjective norm, perceived behavioral control), *additional belief factors* (e.g., triability, content richness), and *external variables* (e.g., demographic characteristics, computer self-efficacy). External variables can be moderators of perceived usefulness and perceived ease of use. The extensions wish to increase TAM's predictive power by adding variables concerning specific *technologies*, *contexts*, and *users*. Several studies have used the TAM and TAM extensions to study the intention to use VR applications in different contexts and have shown that it can effectively be applied [10, 15]. [24] proposed the Technology Acceptance Model 2 (TAM 2), an extension of the TAM model which included five additional external variables and two moderators: *subjective norm, image, job relevance, output quality, result demonstrability, experience and voluntariness*. TAM 2 utilized for studying acceptance of the use of a variety of technologies, in different cultural contexts, over different time periods, and considered as a highly useful, valid, and reliable model for investigating and interpreting teachers' acceptance of technology [25]. In this study *TAM 2 and external factors* according to the research of Teo et al. [9] and the extension of *TAM for VR applications* according to the research of Sagnier et al. [10] were used as basis to compose the research tools.

Teo et al. [9] in their study aimed to provide a framework for understanding Chinese pre-service teachers' acceptance of the pedagogical use of Web 2.0 technologies in their future teaching practice. Their model is based on TAM and TPACK model, adopting from TAM and TPACK, seven factors, including *Perceived usefulness, Perceived ease of use, Perceived Enjoyment, Web 2.0 self-efficacy, Subjective norm, Facilitating conditions, Technological pedagogical and content knowledge (TPACK)* as independent variables and intention to use Web 2.0 technologies (IU) as dependent variable. Focusing on pre-service teachers the study discusses some important predictors of Chinese teachers' intention to use Web 2.0 technologies.

The objective of Sagnier et al., [10] study was to test an extended Technology Acceptance Model developed to study user acceptance of VR applications. The proposed extended model includes *user experience variables*, *variables specific to VR*, and *user characteristics*. Moreover, as user experience with immersive technologies enables a feeling of presence and it can make users feel sick variables related to *presence* and *cybersickness*, included in the model. Additional to the typical TAM variables, the proposed model includes *User Experience* (Pragmatic quality, Hedonic Quality–Stimulation), *Cybersickness* (Nausea, Oculomotor), *Presence* (Ability to act, Ability to examine, Interface quality, Self-assessment of performance, Realism) and *Personal innovativeness*. Table 1 briefly describes definitions for the variables and the items of the research tools adopted in this study.

3 Aim and Research Questions.

The aim of the study was to examine Perceived usefulness and Perceived ease of use for iVR applications by pre-service teachers and their Intention to use them in their teaching practice. Factors affecting these variables also examined and discussed.

The research questions were formulated as:

- What are the *Perceived usefulness* and *Perceived ease of use* for iVR applications by pre-service teachers and their *Intention to use* them in their teaching practice?
- How factors as *Perceived Enjoyment*, *Conditions of Facilitation*, *Ability to act*, *Ability to examine*, *Interface Quality*, *Self-assessment of performance, Realism of VR Applications, Personal Propensity for Innovation* could affect Perceived usefulness, Perceived ease of use and Intention to use?

4 Method

4.1 Description of the Research

The study was a case study. Fifteen (15) pre-service teachers participated in the study (eleven (11) female and four (4) male). All of them were 4th-year students at an undergraduate university level program in Educational Sciences attending the course 'ICT in Education'. The participating students lacked laboratory skills and knowledge about the preparation of aqueous solutions, a topic of particular importance in the field of laboratory chemistry. The sample of the study was a convenient one. The students/pre-service teachers participated in a short duration course during which they worked with Onlabs, a free and open VR educational software preparing an aqueous solution, handling the appropriate equipment in the iVR environment. The iVR application is built on the Unity 3D platform and is based on the Onlabs VR software written in C#. Onlabs supports open education to reap the benefits of VR and offering knowledge based on the theoretical models of Behaviorism, Cognitivism and Constructivism. During the course students as a Head Mounted Display, the VR Headset Oculus rift s was used, a headset that has two Pentile OLED screens, with 1080x1200 clarity in each eye. A pre-questionnaire and a post-questionnaire, based on TAM 2 and external factors according to the research of Teo et al. [9] and the extension of TAM for VR applications according to the research of Sagnier et al. [10] were used as basis to compose the research tools.

4.2 The Research Tools

A pre-questionnaire and a post-questionnaire, based on TAM 2 and external factors according to the research of Teo et al. [9] and the extension of TAM for VR applications according to the research of Sagnier et al. [10] were used as basis to compose the research tools. A total of twenty-four (24) questions composed the pre-questionnaire and a total of forty-two (42) questions composed the pre-questionnaire. In Table 1, the factors/variables used, a description and the questions composing each one are presented. All questions were closed-ended questions with answers on a five-point Likert scale.

Both questionnaires were tested for Validity and Reliability. A Back translation procedure (*English-Greek-English*) implemented. After that three experts in the field of VR applications in education reviewed the questionnaires to ensure content validity. A Pilot use of the pre-questionnaire by two (2) students before the course and a pilot use of the post-questionnaire by the two (2) same students after the course ensured face validity of the research tools. Cronbach's α coefficient was used to examine the internal consistency/of the answers for the two questionnaires [26].

Table 1. The questionnaires.

Factors	Pre-questionnaire	Post-questionnaire
Perceived Ease of Use-PEU *is used to describe the extent to which an individual believes that his/her use of a particular technology would require the least amount of mental and physical effort*	1. Learning to use VR applications in teaching will be easy. 2. Using VR applications in teaching will be clear and understandable. 3. Using VR applications in teaching will be flexible to interact with. 4. It will be easy to become skilful at using VR applications in teaching	
Perceived Usefulness-PU *defines the extent to which an individual believes that the use of a particular technology would enhance his/her job performance.*	1. Using VR applications will improve my teaching performance. 2. Using VR applications will enhance my teaching effectiveness. 3. Using VR applications will increase my productivity in my teaching. 4. VR applications will be useful for my teaching.	
Perceived Enjoyment-PE *defined as the degree to which the application of a particular technology provides pleasure to the user, without taking into account any impact on his/her work*	1. The process of using VR applications in teaching will be pleasant. 2. Using VR applications in teaching will arouse my students' curiosity. 3. Using VR applications in teaching will be exciting. 4. Me and my students will have fun using VR applications in teaching.	
Conditions of Facilitation-CF *the user's beliefs about the possibility of providing resources and infrastructure to facilitate the use of a system/application.*	1. When I need help to use VR applications in teaching, someone will be there to help me. 2. When I need help to learn to use VR applications in teaching, someone will be there to teach me. 3. I will have the resources necessary to teach with VR applications. 4. Training for using VR applications in teaching will be available for me.	
Presence-P *in a virtual environment describes it as the perceptual illusion of nonmedication that occurs when the user fails to acknowledge the technology and interacts with the virtual environment just as they would act in the "real" world*		
Ability to act-AA		1. How much were you able to control the events? 2. How responsive was the environment to actions that you initiated (or performed)? 3. Were you able to anticipate what would happen next in response to the actions that you performed? 4. How completely were you able to actively survey or search the environment?
Ability to examine- AE		1. How closely were you able to examine objects? 2. How well could you examine objects from multiple viewpoints? 3. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?
Interface Quality-IQ		1. How much delay did you experience between your actions and expected outcomes?

	2. How much did the visual display quality interfere with or distract you from performing assigned tasks or required activities? 3. How much did the control devices interfere with the performance of assigned tasks or with other activities?
Self-assessment of performance-SAP	1. How quickly did you adjust to the virtual environment experience? 2. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?
Realism of VR Applications-R	1. How natural did your interactions with the environment seem? 2. How natural was the mechanism which controlled movement through the environment? 3. How compelling was your sense of objects moving through space? 4. How much did your experiences in the virtual environment seem consistent with your real-world experiences? 5. How compelling was your sense of moving around inside the virtual environment? 6. How involved were you in the virtual environment experience?
Personal Propensity for Innovation-PPI *Personal innovativeness is defined as the willingness of an* *individual to try out any new information technology.*	1. If I heard about a new information technology, I would look for ways to experiment with it. 2. Among my peers, I am usually the first to try out new information technologies. 3. In general, I am hesitant to try out new information technologies. 4. I like to experiment with new information technologies.
Intention to Use-IU *is the extent to which users would use/exploit a technology/application*	1. I will use VR applications in my future teaching. 2. I intend to use VR applications as much as possible in my future teaching. 3. I will talk about the positive aspects of using VR applications in my future classroom. 4. I will recommend VR applications to my future colleagues.

Questions in white background are based on the research of Teo et al. (2019) - Questions in grey background are based on the research of Sagnier et al. (2020)

4.3 The Procedure

Students participated in a short course in the frame of the study. Figure 1 describes the stages of the procedure during the short course.

During the course, students were given a simulated experiment of preparing aqueous solution with a given concentration. The experiment procedure is divided into individual steps with little intrinsic cognitive load each. The process of the specific solution preparation experiment is divided into 16 individual steps. In Figure 2 shots from stages 3 and 4 of the process are shown. For each step, the user is given an instruction that is displayed on a virtual screen within the virtual laboratory (Image 3a). The user must follow the instructions to correctly carry out the respective step, using the correct laboratory equipment (Image 3b). In case the user needs help he can ask for it with the appropriate button on the remote control and hints on how the instruction can be carried out are displayed on the virtual screen.

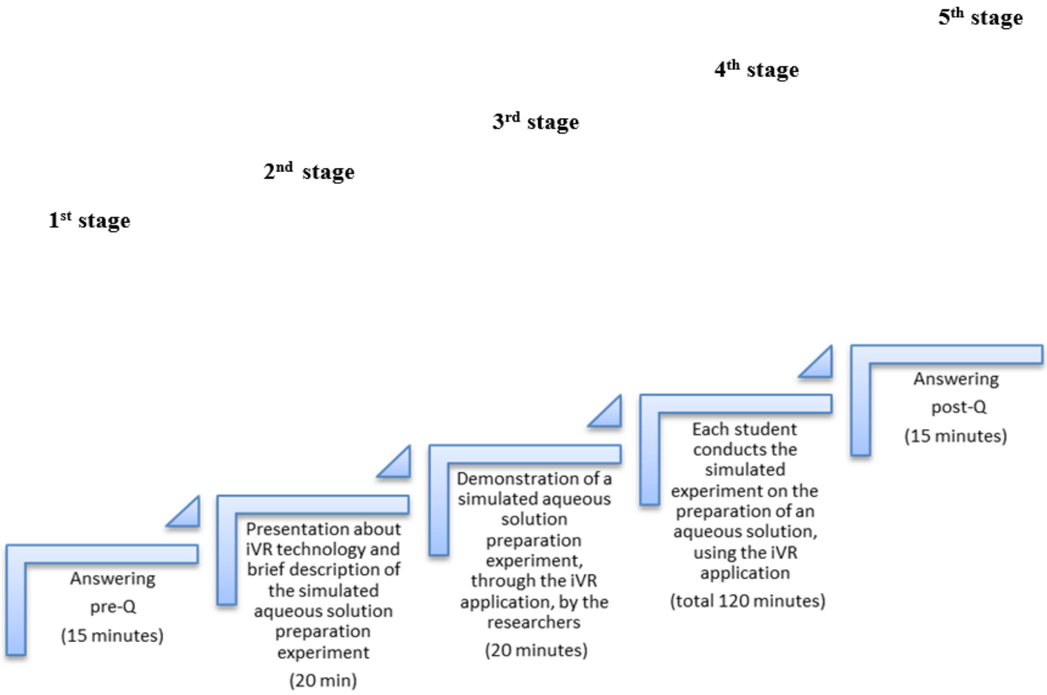


Fig. 1: The five stages of the procedure during the short course.

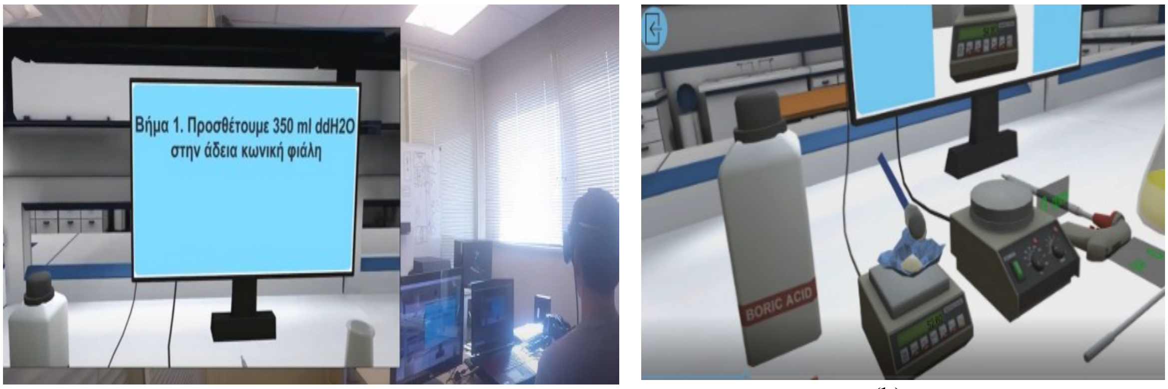
4.4 Data analysis

Descriptive and inferential statistical analysis was used to analyze the data. The values of the factors under investigation were calculated by averaging the values of the responses to the individual questions that compose the factor.

The Shapiro-Wilk normality test for each factor's data performed and non-normal distributions yielded. Data were analyzed using Wilcoxon's Matched-Pairs Signed-Ranks to detect statistically significant differences and Spearman's correlation coefficient (r_s) to detect correlations.

(a) (b)

Fig. 2: Stages of the procedure: (a) Stage 3: Demonstration of the performance of a simulated experiment and (b) Stage 4: Conduction of a simulated experiment by a student.



(a) (b)

Figure 3: Screenshots from Onlabs immersed VR-(a) & (b) User completes the experiment following the instructions step-by-step (Source: Paxinou & Kalles, 2022).

5 Findings and Discussion

Cronbach's α coefficient was marginally acceptable for both the questionnaires before (0.59) and after (0.68). The mean values, the standard deviations, the median values for each factor and the results of the comparisons using Wilcoxon's Matched-Pairs Signed-Ranks are described in table 2.

Students' answers gave *high* values for PU and PE, *moderate* values for PEU, PPI and IU but *low* values for CF before the course. The values of all factors are *higher* after the course but the *same* for PPI as it was as expected. The experience students had with the iVR application enhanced their PU, PEU, PE, CF and IU such applications in their teaching practice. Although the values are higher after the course, the values for PEU, PU, PE are *high*, the values for CF remain *low* and the values for IU are *marginally higher.* The data from the small sample size were not enough to highlight statistically significant correlations among the factors. The statistically significant correlations arose are as: *Ability to act* seems to be correlated moderately with *Interface Quality* (r_s = -.616, $p < .05$) and *Self-assessment of performance* (r_s = .660, $p < .01$). *Interface Quality* seems to be correlated moderately with *Intention to Use* (r_s = .609, p < .05).

Table 2. Mean values, standard deviations, and median values for each factor.

Factors	Pre-questionnaire			Post-questionnaire			
	$\bar{x}$	s	$\tilde{x}$	$\bar{x}$	s	$\tilde{x}$	z, p
Perceived Ease of Use-PEU	3.4	.21	3.5	3.7	.31	3.5	-2.53, <.05
Perceived Usefulness-PU	4.0	.01	4	4.3	.29	4.25	-2.87, <.01
Perceived Enjoyment-PE	3.9	.13	4	4.2	.37	4.0	-2.23, <.05
Conditions of Facilitation-CF	2.1	.13	2.25	2.5	.46	2.25	-2.41, <.05
Presence-P							
Ability to act-AA				3.6	.46	4	
Ability to examine-AE				3.5	.56	3.67	
Interface Quality-IQ				2.4	.46	3.33	
Self-assessment of performance-SAP				3.6	.34	3.5	
Realism of VR Applications-R				4.3	.36		
Personal Propensity for Innovation -PPI	2.5	0.51	2	2.5	.52	2.0	-
Intention to Use-IU	3.1	0.55	3	3.3	.47	3.0	-2.54, <.05

6 Conclusion

The study aimed to investigate the acceptance of iVR applications by pre-service teachers/students who attended an undergraduate university level program in Educational Sciences, and their intention to use iVR software in the future as teachers, in their educational practice. The pre-service teachers participated in a short duration course during which they worked with Onlabs preparing an aqueous solution, handling the appropriate equipment in the immersive virtual environment. A pre-questionnaire and a post-questionnaire, based on TAM extensions related with VR used as research tools.

According to the findings, students before the course showed *high* values for Perceived Usefulness and Perceived Enjoyment, *moderate* values for Perceived Ease of Use, Personal Propensity for Innovation, and Intention to Use but *low* values for Conditions of Facilitation. The values of all factors are *higher* after the course but the *same* for Personal Propensity for Innovation as it was as expected. The experience students had with the iVR application enhanced their Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment but not their values for Conditions of Facilitation. The values for Intention to Use are *marginally higher.* The Ability to act seems to be correlated with Interface Quality and Self-assessment of performance and Interface Quality seems to be correlated with Intention to Use.

The study is a case study, the sample size is small, the duration of the course is short, and students worked only with one iVR application. The conclusions cannot be generalized but can contribute to the discussion concerning the benefits of iVR in education, the adoption of iVR applications by teachers and the factors affecting this adoption.

Disclosure of Interests.

The authors have no competing interests to declare that are relevant to the content of this article.

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