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Doctoral Dissertation

VIRTUAL REALITY AS A MEDIUM FOR ATTITUDE CHANGE

Maria Christofi

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Approval Form

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ABSTRACT

The study of attitude change has been of interest for decades, with social professionals, having to deal with real actors, written words, and relying on traditional software and hardware to achieve their goals. Virtual Reality (VR), due to its immersive, transformative and engaging form, and its ability to make users feel like they are part of the virtual world that surrounds them, can be a useful medium to affect peoples' attitudes, including emotions, behavior, knowledge, and beliefs over an entity.

This dissertation, through a series of three experimental studies, delves into whether VR can be used as a medium for attitude change, in order to modernize the existing traditional methods used by social professionals.

Attitudes can be categorized into affective, behavioural and cognitive attitudes. They include our emotions, behavior, and knowledge about an entity. In this dissertation, focus is given to changing affective attitudes and more specifically empathy toward stigmatized groups and cognitive attitudes and more specifically increasing knowledge about an archeological site in Cyprus.

Thus, the first study, offered the ability to participants, to experience through VR, a substance use situation in a virtual school from different perspectives (a teacher and two different students, one of them experiencing hallucinations due to drug use), to change affective attitudes and more specifically, induce empathy about drug users. The VR intervention elicited a statistically significant difference in participants ability, those who viewed the scenario through the drug users' perspective, the ability to relate to students going through drug problems. An increase in participants' heart rate after the experiment, compared to their heart rate before the experiment, indicates that they experienced a stressful condition as there was a significant difference in their reported negative mood states as well.

The second study explored VR's ability to support sensorimotor contingencies, on changing affective attitudes and more specifically inducing empathy toward drug users. It was a comparison between a VR and a non-VR system that was not offering any sensorimotor contingencies. Results showed a significant positive correlation between the closeness to the drug user and empathy in the VR group and that both conditions achieved an increase in positive attitudes.

The third study dealt with cognitive attitudes and more specifically increasing knowledge about a part of Cyprus' cultural heritage and more specifically an archaeological site. It was investigated whether participants' attitudes and knowledge toward archaeology can be affected by using an immersive VR and a Desktop Application, taking users on a virtual tour of an archaeological site in Cyprus. There was not a significant change in attitudes toward archaeology between the two groups. Interestingly, the VR Application was found to be less effective in acquiring and memorizing new information about the archaeological site.

Results from these studies show the potential of VR as a medium for attitude change and more specifically for affective attitudes and more specifically inducing empathy for drug users and positive attitudes for them. VR-based methods did not significantly increase knowledge or a change in attitudes towards an archaeological site. Findings showed that more research is needed regarding what could make VR-based methods more effective for bringing cognitive attitude change like knowledge acquisition, with promising results in inducing empathy for stigmatized groups.

Keywords: Virtual Reality, attitudes, empathy, knowledge, perspective-taking

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LIST OF ABBREVIATIONS

1PP:	First-Person Perspective
2D:	Two dimensional
3D:	Three dimensional
AIDS:	Acquired immunodeficiency syndrome
CV:	Consumer Version
EE:	Embodied Experiences
EEG:	Electroencephalography
EVR:	Embodied Virtual Reality
FoV:	Field of view
HMD:	Head Mounted Display
HR:	Heart rate
HRV:	Heart rate variability
HTC:	High Tech Computer Corporation
IVE:	Immersive Virtual Environment
IVET:	Immersive Virtual Environment Technology
OLED:	Organic Light Emitting Diodes
PC:	Personal Computer
PI:	Place Illusion
Psi:	Plausibility Illusion
RHI:	Rubber Hand Illusion
SC:	Sensorimotor Contingencies
SD:	Standard Deviation
SoE:	Sense of Embodiment
TV:	Television

UN:	United Nations
VB:	Virtual body
VE:	Virtual Environment
VR:	Virtual Reality
VRPT:	Virtual Reality Perspective Taking

1 Introduction

Attitudes as a concept, include our emotions associated with an entity, like a person or an object, our behavior toward it and our beliefs and knowledge regarding it.

In the study of attitudes, prior to World World II, emphasis was given to their definition and measurement, with most studies being surveys and studies providing correlational findings (Simonson, & Maushak, 1996). During World World II, attitude change was an important topic for Army-sponsored research by Carl Hovland, an experimental psychologist. He used experimental techniques were used to study the persuasive effects of propaganda (Hovland, Janis & Kelley, 1953). One of the first examples of attitude change studies, by Simonson in 1977, used Festingers' (1962) cognitive dissonance theory, in order to improve student attitude toward an instructional activity. The student achievement in this activity was then measured to determine if achievement was influenced by a change in student attitude toward instruction. This study was one of the first to show that, in an experimental situation with real-world implications, it was possible and simple, to modify student attitudes toward an instructional event, in this case a college course.

Traditionally, social professionals like psychologists and educators had to use written words, real actors, and not intuitive software to achieve a change in attitudes in people, which was inconvenient and costly in resources like time and money.

Advancements in technology and more specifically in the field of VR, now give social professionals powerful tools to make this process faster and cheaper. Nowadays, they can use virtual environments instead of written words or simple 2D/3D graphics, digital agents instead of hiring real actors, VR hardware and high-end PCs. This combination makes the whole process of attitude change more versatile, customizable, and repetitive, in a controlled environment. Virtual environments provide social professionals, who are concerned with attitude change, not only with a way to assess attitudes unobtrusively but to change them covertly as well (Blascovich & McCall, 2010).

1.1 VR as a medium for attitude change

VR offers us unique features which makes it a medium to consider regarding attitude change. VR's immersive form, which includes the technological features that allow

users to feel present in a virtual world (Slater & Wilbur, 1997), the illusion of being in the virtual place, which is defined as Place Illusion (PI), and the extent to which the situation and events seemed to be really happening, which is defined as Plausibility Illusion (Psi) (Slater, 2009), all differentiate it greatly to other forms of media.

VR can be used to trick people with optical and sensory illusions, and by doing so, people can adopt in an instance any other form (human or non-human), no matter how different, as their own. A person wearing a head-mounted display (HMD), that offers wide field-of-view stereoscopic vision, can be immersed in a computer generated, three-dimensional environment, in which they can explore and interact. Moreover, by wearing specialized glasses that track head movements and by looking down toward his feet, they can see a virtual body spatially coincident with their own. The brain at that point gets a powerful cue to feel that this virtual body is their own, because in real life, when that person does the same movement, they see, obviously, their own body. Taking this a step further, using real-time motion capture, that person can move their real body and see the virtual version move correspondingly. This setup is known as embodiment in a virtual world (Slater & Sanchez-Vives, 2014).

Your brain at that point has the perceptual illusion that an alternate virtual body is your own, the so-called feeling of body ownership. This phenomenon comes from the famous "Rubber Hand Illusion", an illusion discovered by psychologists in Pennsylvania (Botvinick & Cohen, 1998). In this illusion, in front of the subjects, a rubber hand is located, while their corresponding (real) hand is hidden from their view. Then, the subjects see the rubber hand being stroked simultaneously as the real hidden hand in the same way and they have the illusion that the rubber hand is their own. When the rubber hand is suddenly attacked, the subjects display anxiety and reflex behavior.

As technology is evolving, we can design and develop simple or complex scenarios for learning and emotional stories for attitude change. People can transport by simply wearing an HMD to any place, real or imaginary, and learn about the culture and customs of ancient civilizations. Additionally, with the ability to create and customize our virtual representations in a virtual world and the form or type of our virtual body can be quite different from our actual body. A person immersed in a virtual world and embodied in a virtual body different than their own can see the world from a different perspective, as a member of a stigmatized group. Through virtually experiencing the life

of the stigmatized, the person can “take their place” and potentially feel more empathetic toward them.

This transformative power of VR makes it a powerful tool in social professionals’ efforts to achieve change in attitudes.

1.2 Importance of empathy and knowledge

The attitudes definition used in this dissertation, Ostroms’ (1969) ABC model, categorizes attitudes as (a) affective; dealing with emotions and feeling about an entity, (b) behavioral; dealing with our actions and behavior toward an entity and (c) cognitive; our beliefs and knowledge regarding an entity. This dissertation will focus on affective and cognitive attitudes and more specifically empathy and knowledge, respectively.

1.2.1 Regarding empathy

VR can be used as a tool to cultivate empathy skills and combat false perceptions over stigmatized people. Stereotypes, prejudice, and discrimination all exist in our world. Unconsciously (or not) in our minds, we are “hanging labels” on people. If a person speeds up on the highway and overcomes us, we get angry, shout, and label that person as “bad” for speeding. We associate a certain quality, which is usually a negative one, with a person or a group of people, although this association is not proven. Stereotypes are leading to prejudice (Devine, 1989), which is the most visible expression of intolerance and discrimination (Zick, Küpper & Hövermann, 2011).

Discrimination, on the other hand, has been found to directly affect the social status, psychological well-being, and physical health of the stigmatized. Members of stigmatized groups are discriminated against in their workplace, educational settings, health care, and the criminal justice system (Sifanius & Pratto, 2001). They are even discriminated against in their own family (Crandall, 1995). Kantontoka (n.d.) states that stigma surrounds mental illness and there is a belief that these people are difficult and are not able to make decisions. Stigmatized people are abused, rejected, isolated, and excluded from health care.

A reliable method that has been shown in reducing negative social stereotyping is perspective taking (imagining what it is to become somebody else, and undergo specific

experiences) (Zaki & Ochsner, 2012; Tomasello, 2009; Perdue & Gurtman, 1990). Using role-play people are transported, mentally, into the mind of another. Psychologists argue that our ability to cooperate with and understand others has supported our species' success in winning the cross-species competition for global domination (Zaki & Ochsner, 2012; Tomasello, 2009).

These abilities are supported by the multifaceted psychological construct of empathy, the ability to understand and share the feelings of another. Regarding empathy, Lori Melichar, the director at the philanthropic foundation Robert Wood Johnson Foundation said in an interview (Cimons, 2016) that "Empathy is at the center of our collective efforts to build a culture of health. If we do not understand the perspectives of others, we can never help others pursue healthier lives". Additionally, a survey has shown evidence that interactive virtual worlds can have an impact on our well-being: our attitude of judging life positively and feeling good (Christoforou & Michael-Grigoriou, 2015).

1.2.2 Regarding knowledge

The use of VR in the field of education has attracted the interest of the scientific community and social professionals that want to bring modern technologies into the learning process (Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou & Lanitis, 2019b). VR provides its users the ability to experience realistic scenarios in which they might react to, naturally and realistically, because VR simulates reality (Parsons, Bowerly, Buckwalter & Rizzo, 2007; Eschenbrenner, Nah & Siau, 2008). VR has also the advantage of the three-dimensional representation of objects, which is important for learning and better visualizing information objects and places, which would otherwise be just pictures in a school book (Salzman, Dede, Loftin & Chen, 1999). It was shown that additional sensory cues provide a more realistic and engaging learning experience (Psotka, 1996). Researchers are demonstrating that when students actually experience learning material in an interactive video game context, they learn in unique manners (Barab et al., 2005). The knowledge gained within the VRE can be transferred to the real world but also the knowledge from the real world can be used within the VR

environment (Eschenbrenner et al.,2008; Huang, Backman, Chang, Backman, & McGuire, 2013; Parsons et al., 2007).

1.3 Problem and Motivation

The act of changing attitudes includes many aspects, as mentioned above, like changing affective attitudes, like inducing empathy for stigmatized people and changing cognitive attitudes, like increasing knowledge about a subject.

Through the years, social professionals have tried many mediums, from advertisements on TV, to articles in newspapers, documentaries, and visits to schools to bring attitude change in people. People stuck in their everyday life routines, do not have the leisure of time to watch TV, or watch documentaries, or even travel and visit sites in other countries, or even in their own country. Regarding substance use from students inside the school perimeter, there is a lack of empathy from teachers for these students, and a lack of knowledge on how to deal these delicate situations. Even everyday people, have preconceived beliefs about drug users and the reasoning for their acts, ultimately leaving drug users being discriminated against in their efforts to re-enter society and live a normal life.

Traditional methods used by social professionals for attitude change are outdated and not engaging enough. Many technologies, especially less immersive than VR, like mobile phones, vignettes and personal computers have been used in the past to achieve attitude change. VR and its transformative power are allowing people to view the perspective of other people or transfer them into imaginary places and scenarios.

VR from its first invention in the 50s, and its popularization in the 80s by Jaron Lanier, has been utilized to transport us into realistic or imaginary worlds, due to its immersive form. From entertainment to learning, rehabilitation to tourism, its uses vary and increase as it becomes more accessible and affordable to the everyday user. VR has several features that could be useful in the learning process. In VR we can present 3D virtual environments and give audio, visual and sometimes even haptic feedback. Visualizing in 3D, learning materials, can be beneficial when visualizing is important. Although visualization can be done with the use of a video, they are strictly passive, whereas VR offers the interactivity and the feedback which can be useful and beneficial as it promotes active instead of passive learning (Allcoat & von Mühlenen, 2018).

Additionally, when VR is combined with motion tracking equipment, it “gives life”, in the form of a virtual avatar, to the user, it affects the users’ perception of themselves and their attitudes. These aspects make it a modern medium that can help in the effort to induce empathy and increase knowledge on a subject with a more engaging way than before.

The results of this thesis will contribute to the attitude change research scene, and make social professionals previously sticking to using traditional methods of researching such issues, to modernize their approaches and make them more engaging.

1.4 Research Questions

1. Do different perspectives change the affective attitudes of teachers toward drug users in a school through a virtual school environment?
2. Do sensorimotor contingencies supported by a VR system, change the affective attitudes induced toward drug users?
3. Can the use of a VR-based simulation change peoples’ cognitive attitudes about an archaeological site?

1.5 Structure of the thesis

This dissertation contains eight chapters, including this introduction.

- **Chapter 2: Background Knowledge.**
  This chapter reviews the most significant terms involved including VR, attitudes, empathy, prejudice, stereotypes, discrimination, and social stigma, and how through perspective taking we can achieve empathy and a change in attitudes.
- **Chapter 3: Methodological framework.**
  This chapter presents the research design followed in this dissertation. It explains the procedure with which, participants were recruited, how data is being collected and how they are analyzed. Moreover, ethical considerations are presented.

- **Chapter 4: Study 1 – Changing the affective attitudes of teachers for drug users in schools.**

  This chapter focused on the first conducted study of this dissertation, which through a VR simulation, and by using different points of views of the same scenario, aimed to induce empathy to teachers toward drug users in a virtual school area.
- **Chapter 5: Study 2 – Changing affective attitudes toward drug users through a Virtual Reality simulation of their life.**

  This chapter presents the second conducted study of this dissertation, which examined how a VR system offering sensorimotor contingencies compares to a non-VR system that offers none, in inducing empathy and changing attitudes toward drug users.
- **Chapter 6: Study 3 – Changing peoples' cognitive attitudes about an archaeological site.**

  This chapter focuses on the third and final study that was conducted for this dissertation, which delved into whether VR can increase knowledge and change attitudes for our archaeology and cultural heritage, through a virtual simulation of an archaeological site tour.
- **Chapter 7: Conclusions.**

  This chapter summarizes the main findings regarding the research questions. Additionally, it showcases the contributions of the research alongside its limitations. Finally, future work for the current research is presented with some concluding remarks.

2 Background Knowledge

This chapter aims to review the state of the literature regarding VR and its utilization in the field of attitude change, definition of the most important terms of this dissertation, including attitudes, empathy and perspective taking and how it can help in the efforts of inducing empathy and a change in attitudes.

2.1 Terms and Definitions

2.1.1 Virtual Reality

In Virtual Reality, a person is immersed in an environment that is realized through computer-controlled display systems and might be able to effect changes in that environment (Sanchez-Vives & Slater, 2005).

VR has been used extensively through the years in a variety of fields like in education (Freina & Ott, 2015; Michael-Grigoriou, Yiannakou & Christofi, 2017), in training (Seidel & Chatelier, 2013; Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou & Lanitis, 2019), in cultural heritage (Rua & Alvito, 2011; Christofi et al. 2018), in psychology (Wilson & Soranzo, 2015), exposure therapy for phobias and disorders (Opriş et al, 2012; Botella et al. 2017; Christofi & Michael-Grigoriou, 2016), physical rehabilitation (Najm et. al, 2020) as well as tourism (Guttentag, 2010; Tussyadiah, Wang & Jia, 2017).

Often used as a training tool from astronauts to medical staff and teachers, VR can also expand our knowledge and skills over a subject. In the area of training, immersive VR and its ability to offer interaction with virtual objects and visualization (Norrby, Grebner, Eriksson, & Bostrom, 2015) could be extremely helpful. People can be trained in a virtual environment alone or in a shared environment with others. Virtual environments have many advantages over real ones; they can be used to experiment safely, and they are controllable. Any environment can be created, realistic or fictional, for the purposes of the training. When using VR technology for training, it is possible to repeat training exercises as many times as required without additional cost. VR has also the advantage of the three-dimensional representation of objects, which is important for understanding and learning (Stavroulia et al, 2019b).

2.1.1.1 Immersion and Sensorimotor Contingencies

Human beings, in order to perceive the world around them, use the data that their senses are picking out, their vision, touch, force, taste, smell and sound.

The technical goal of VR is to replace our real sense perceptions by the computer-generated ones. If sensory perceptions are successfully substituted, then the brain has no option but to realize, as the new reality, the virtual one (Slater & Sanchez-Vives, 2016).

Immersion describes the technical capabilities of a system like wide field-of-view vision, stereo, head tracking, low-latency from head move to display, high-resolution displays, haptic feedback (Slater & Sanchez-Vives, 2016; Slater & Wilbur, 1997). According to Slater and Sanchez-Vives (2016) "We say that system A is more immersive than system B if A can be used to simulate the perception afforded by B but not vice versa". An example of this can be that an HMD is more immersive than a personal computer since it can offer the ability to turn your head 360 degrees to view the virtual space around you, which the computer cannot do, since the moment you turn your head away from the computer screen, you will view the physical space you are located into.

The researchers also noted that immersive systems can be characterized by the sensorimotor contingencies (SCs) that they support, which perceives the environment through the use of the body in a natural way. This could be, for example, moving your head and eyes to change gaze direction or the use of haptic gloves in order to touch virtual objects and move them around (O'Regan & Noë, 2001; Noë, 2004).

2.1.1.2 Place Illusion and Plausibility

A system that can support SCs close to those in the physical reality can induce an illusion of you actually being located in that virtual environment. This is defined as Place Illusion (PI) and it refers to the sense of "being there" in a virtual world (Slater, 2009). It has also been defined as "presence" or "telepresence" (Slater, & Wilbur, 1997; Draper, Kaber, & Usher, 1998), it is rooted in teleoperator systems, and it is the feeling of being at the place of the remote physical robot that the user is operating (Minsky, 1980).

While PI is the illusion of you really "being" in the virtual world, the Plausibility of the situation (Psi) is the illusion that "what is apparently happening is really happening, even though you know that it is not" (Slater, 2009). According to Slater and Sanchez-Vives (2014), this seems to be a function of what the environment can offer the user like (a) whether and the extent of the events occurring in the virtual world refer specifically to the user, (b) the extent of the events respond directly to the actions of the user (e.g. the user talks to an avatar in the virtual world, and the avatar responds to the user) and (c) the credibility of the virtual world compared to the user's expectations.

On the other hand, the Plausibility of the Virtual People, is the extent to which the users feel that the virtual people are behaving, moving, reacting as if they were real people. This illusion was important in the first and second study, as the scenarios in the virtual world included other avatar who surrounded the participants and some were talking to them too, and it had to be believable.

2.1.1.3 Sense of Embodiment in VR

Jaron Lanier, in the 1980s, realized that VR can be used to transform the self by giving participants virtual bodies, in particular a body lobster of a lobster, which obviously ahs more limbs than a human body. His observation was that people learned quickly to inhabit different bodies and still interact with the virtual world (Lanier, 2010), which he called "homuncular flexibility". Although those results were never published, interest remains in that phenomenon. The RHI (Botvinick & Cohen, 1998), demonstrated that people can have the illusion of owning a non-real part of the body, which was the fake hand. In VR, a persuasive virtual environment requires that the participant be able to see and use his (virtual) body, like in the real world. The degree to which the participant can control their virtual body affects the feeling that this body belongs to them. Similar techniques are used in VR, using head mounted displays, not only for a hand but also for the whole body. In virtual reality, synchronized stimulation is usually visual (the person sees their virtual body parts moving respectively to their actual movements), but additional stimulation (such as tactile) enhances the illusion (Kilteni, Maselli, Kording & Slater, 2015). This phenomenon in VR is called embodiment.

The term “embodiment”, in this dissertation, is used for the VR setup in which a virtual body is spatially coincident with your real body and you see through the eyes of that virtual body, with various types of synchronous multisensory correlation (Slater & Sanchez-Vives, 2014). VR embodiment was used in the first two studies, which dealt with inducing empathy for drug users, as it was deemed necessary for the participants to be embodied in the virtual body of a drug user, to virtually take his place and experience their life.

In 2012, Kilteni, Groten & Slater (2012) created the term “Sense of Embodiment” (SoE) to refer to the ensemble of sensations that arise in conjunction with being inside, having, and controlling a body especially in relation to VR applications. More specifically, they define SoE as “SoE toward a body B is the sense that emerges when B's properties are processed as if they were the properties of one's own biological body”. They state that SoE consists of three subcomponents: the sense of self-location, the sense of agency, and the sense of body ownership (Kilteni, Groten & Slater, 2012).

Self-location is a determinate volume in space where one feels to be located. The sense of self-location refers to one's spatial experience of being inside a body and it does not refer to the spatial experience of being inside a world (with or without a body).

According to Gallagher (2000) the sense of agency is “the sense that I am the one who is causing or generating an action”. Tsakiris, Prabhu & Haggard (2006) defined body ownership as “the sense that one's own body is the source of sensations”. As they note, on an “additive” model, agency and body-ownership are strongly related; the ability to control actions is a powerful cue to body-ownership. Body ownership illusions refer to the illusory perception of non-bodily objects (e.g., artificial limbs) as being parts of one's own body and the sources of the associated bodily sensations, such as touch (Kilteni, Maselli, Kording & Slater, 2015).

2.1.1.4 Effects of Embodiment

In a virtual world, you can have any kind of virtual body. This can lead to behavior changes which have been also studied in some scenarios, like when having a virtual body of a different race or feeling like being a child.

Yee & Bailenson in their 2007 set of studies presented that our self-representations have a significant and instantaneous impact on our behavior. In 2 experimental studies, they explored the hypothesis that an individual's behavior conforms to their digital self-representation independent of how others perceive them, a process they termed as the Proteus Effect. In the first study, participants assigned to more attractive avatars in immersive virtual environments were more intimate with confederates in a self-disclosure and interpersonal distance task than participants assigned to less attractive avatars and in their second study, participants assigned taller avatars behaved more confidently in a negotiation task than participants assigned shorter avatars.

In a study by Kilteni et al. (2013), 36 Caucasian people participated in a between-groups experiment where they played a West-African Djembe hand drum while immersed in IVR and with a virtual body that substituted their own. Only those with the Casual Dark-Skinned representation showed significant increases in their movement patterns for drumming compared to the baseline condition and compared with those embodied in the Formal Light-Skinned body. Moreover, the stronger the illusion of body ownership in the Casual Dark-Skinned condition, the greater this behavioral change.

Using an immersive first-person 3D computer game, Christou & Michael (2014), investigated if the visual characteristics of a player's avatar influence their behavior. Two types of gender-matched biped avatar were used: Normal looking Humanoids and tougher looking Aliens. Their results provide evidence for non-verbal behavioral differences in performance based on the visual appearance of the avatar adopted by the player in a first-person action game.

Michael & Slater (2012) investigated the consequences of virtual body ownership on weightlifting endurance time. They found that the critical factor is the level of the illusion of ownership over the virtual body – the highest levels of ownership over a strong body lead to enhancement of performance with respect to the baseline condition and that the induction of a virtual body ownership illusion, in their case, by visual-motor synchrony, may when successful, lead to temporary changes in behavior, attitudes or, in this case, performance, concomitant with the form of the virtual body.

An interesting subject to study is how people would react to seeing their virtual future selves. This has been studied by Hershfield et al., 2011, where, in four studies, participants interacted with realistic computer renderings of their future selves using

immersive virtual reality hardware and interactive decision aids. In all cases, those who interacted with their virtual future selves exhibited an increased tendency to accept later monetary rewards over immediate ones.

Fox et al. in 2009 conducted a study with a between-subjects design (N = 69) where they examined the role of presence in the imitation of a virtual model. Through immersive virtual environment technology (IVET) they created photorealistic virtual representations of the self that were depicted eating food in a virtual world. They showed that presence did indeed affect imitation, but that the effects varied for men and women in accordance with previous research on sex differences in eating behavior. Men who experienced high presence were more likely than low presence men to imitate the virtual model and eat candy, whereas women who experienced high presence were more likely than low presence women to suppress the behavior and not eat candy.

2.1.1 Why Virtual Reality?

Traditional and low immersive perspective taking media (imagination, articles, TV, movies) has been used to transfer people into the minds and lives of people, and in imaginary scenarios. VR offers the opportunity for people to be immersed in a virtual world that surrounds them and react to their actions and virtually experience any given situation. This is useful when trying to present a virtual environment which people are used to seeing in school books as pictures, like it was done in study 3, where we recreated an archaeological site in a VR application.

The high level of immersion, sense of presence, and the ability to vividly experience any situation from any perspective uniquely position VR as a potentially effective attitude change medium. VR allows users to move their perspectives to different scenarios and universes. One can furthermore play different roles from the perspective of different avatars. The ability of immersive VR to displace the first-person point of view relates directly to perspective taking and role playing (Ventura et al, 2020), and this was utilized in the first study, where the participants had to view the same scenario through perspective of two different people.

When real time body tracking is also available, it allows people to virtually inhabit another body. This sense of embodiment that people usually experience, makes them

feel that they are experiencing the events that their avatar is, they “walk their shoes”. Embodiment was used in study 1 and 2, as the focus was to induce empathy toward drug users, and it was important for the participants to experience the scenarios, through the eyes of that person.

2.1.2 Attitudes

In this dissertation, attitude change is studied. In this sub section, the definition of attitudes is presented, and the different measurement methods used.

2.1.2.1 Attitudes definition

“Attitudes” is a broad concept, and as such, cannot be defined so simply. Eagly and Chaiken (1993, p.1) defined attitudes as “...a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor”.

A broader definition states that an attitude is "a relatively enduring organization of beliefs, feelings, and behavioral tendencies toward socially significant objects, groups, events or symbols" (Hogg & Vaughan 2005). For example, a person who believes a particular ethnic group is lazy and aggressive may feel dislike for such people and therefore intend to act in a discriminatory manner.

A similar, clear, and structured definition is the ABC model of attitudes (Ostrom, 1969), and will be the one used in this thesis, as explained in the following subsection.

2.1.2.2 ABC model of attitudes

Ostrom’s ABC model (1969) of attitudes (Figure 1), defines the three components of attitudes as A (affect), B (behavior), and C (cognition).

- **Affective component:** this involves a person’s feelings or emotions about the attitude entities.
- **Behavioral component:** It consists of a person’s tendencies to behave in a particular way toward an object. This means that our attitudes toward an object influence the way we act or behave toward it.
- **Cognitive component:** The cognitive component of attitudes refers to the beliefs, thoughts, and attributes that we would associate with an object. It is the

opinion or belief segment of an attitude. It refers to that part of attitude which is related to the general knowledge of a person.

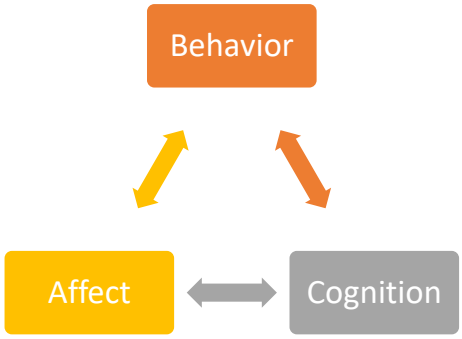


Figure 1: The ABCs of attitudes

Focus on this dissertation will be given in affective attitudes (empathy) and cognitive attitudes (knowledge).

2.1.2.3 Explicit and implicit attitudes and their measurement

The measurement of attitudes has been of interest for decades, and it has been a complex process, as attitudes are related sometimes to social acceptance and our self-image (McLeod, 2018). Attitudes can be explicit and implicit. Explicit attitudes are those that we are consciously aware of and that clearly influence our behaviors and beliefs. Implicit attitudes are unconscious but still influence our beliefs and behaviors.

They have long been measured by using self-report scales, which directly ask a person to evaluate an attitude object by checking a numeric response on single or multiple items (Eagly & Chaiken, 1993). Original measures, like scaling techniques and self-report questionnaires, include the ones from Likert (1932), Thurstone (1928) and Guttman (1954).

Regarding their measurement of implicit attitudes, a variety of implicit attitude measures has been introduced (Fazio & Olson, 2003), with the most popular and used being the implicit association test - IAT (Greenwald, McGhee & Schwart, 1998). Implicit proxemic indicators (e.g., interpersonal distance, personal space, head orientation) of attitudes preceded the appearance of implicit measures based on the relationship between associations of objects, evaluations and response times (Hall,

1963). Past difficulties associated with the recording and scoring of proxemic measures in even the simplest physical experimental venues, can be easily solved by researchers and developers nowadays, as software and game engines can easily record every objects position, rotation and distance with any other object or subject in the virtual world, giving research a pool of data to work with and extract information from. Additionally, by using the HMDs' head tracking, we can get information in real time about the users' head position and rotation, and record data like users' eye gaze direction (Kyrlitsias, Michael-Grigoriou, Banakou, & Christofi, 2020).

A review of more than 100 studies and more than 2.5 million IATs completed online reveals that explicit (self-report) and implicit attitudes both help predict people's behaviors and judgments (Greenwald & others, 2008; Nosek & others, 2007). Thus, explicit and implicit attitudes may together predict behavior better than either alone (Spence & Townsend, 2007).

In this dissertation, a mixture of methods was used to measure participants attitudes. Explicit attitudes like empathy in Study 1 and 2 and knowledge in Study 3 were measured with questionnaires. Participant's emotional state in the first two studies like positive and negative mood states and personal distress were measured using both questionnaires, EEG and Heart Rate.

2.1.3 Empathy

Extensive research by Dan Batson has shown that perspective taking can lead to an increase of empathy, and this can lead to prosocial behaviors toward not only members of stigmatized groups but changing attitudes toward stigmatized groups as a whole (Batson, Early & Salvarani, 1997; Batson et al. 2003; Lamm, Batson & Decety, 2007). Research involving the concept of empathy can be quite a challenge for researchers in disciplines ranging from social and clinical psychology to computer science as well as individual differences. Part of this challenge derives from the lack of a universal definition for empathy.

There has been a huge empirical and theoretical literature concerning the definition of empathy which ultimately leads to semantic confusion. Previous investigators and theorists have taken two main approaches to the study of empathy. The first approach emphasizes "cognitive empathy" which can be defined as the process of understanding

another person's perspective. The second approach emphasizes “affective empathy” defined as an observer's emotional response to the affective state of others. Recently, researchers have adopted a more multi-dimensional approach, acknowledging that both components are an integral part of empathy. This approach views the cognitive and affective components of empathy as two separate, but related constructs (Davis, 1983).

Empathy, in this thesis, will be defined as the ability to connect emotionally with another individual and understanding their perspective (Galinsky, Maddux & White, 2008; Davis, 1983).

2.1.4 Perspective-taking

Perspective taking and empathy are related but at the same time distinct social competencies. Perspective taking can be defined as the cognitive capacity to perceive the world from another person’s viewpoint (Galinsky, Maddux & White, 2008; Davis, 1983). Extensive research by Dan Batson has shown that perspective taking can lead to an increase of empathy, and this can lead to prosocial behaviors toward not only members of stigmatized groups but changing attitudes toward stigmatized groups as a whole (Batson, Early & Salvarani, 1997; Batson et al. 2003; Lamm, Batson & Decety, 2007).

2.1.4.1 Traditional perspective-taking

Traditional perspective taking tasks, where participants are asked to imagine what it would be like to be someone else have been used in the past in many circumstances. These include asking female college students to imagine the daily lives of and feelings of various stigmatized groups, such as AIDS patients and homeless persons to promote more positive attitudes toward them (Batson et al., 1997), having able-bodied college students travel around their campus in a wheelchair to create more positive attitudes toward the disabled individuals Clore & Jeffery (1972), and having Arab students reading a letter from a Jewish mother to their child to decrease hostility toward Israelis (Shechtman & Tanus, 2006).

2.1.4.2 Non-VR interventions

Attempts to promote empathy have been made using mediated interventions like interactive narratives, printed media (Eckel, Grossman & Milano, 2007), TV and video games (Gentile, 2009). Each of these interventions delivers the desired information in many ways, relying on the human senses. TV, for example, offers visual and audio content but a book relies only on the visual system of people.

These media also differ in their level of immersion and interactivity. People cannot interact with a TV but can interact with a video game or an application on their phone. Interactivity has been linked to higher levels of presence (Hand & Varan, 2008).

2.2 Theoretical framework

Several attitude change theories have been proposed in the literature (Eagly & Chaiken, 1993; O'Keefe, 2015; Simonson, & Maushak, 1996). The affective-cognitive consistency theory examines the relationship between attitudes and beliefs (Rosenberg, 1956).

This theory states that when a person's attitudes toward an object and knowledge about it are inconsistent then an unstable state occurs. When providing a person with new information that changes the cognitive component of attitude it will tend to cause that individual to change overall attitudes toward an object. Persuasive communications try to change the affective component of an attitude system by changing the cognitive component of attitude.

This dissertation will use this theory as a basis and build upon it to bring attitude change. Through the use of VR as the persuasive communication in this case, this dissertation will attempt to modernize social professionals' approaches into attitude change and make them more engaging. By immersing people into a virtual world we will attempt to change their affective and cognitive attitudes.

2.3 Literature Review

2.3.1 Empathy in VR applications

The ground-breaking rise of the field of Virtual Reality in the last few years offers new ways to induce empathy in people. With VR, we can create experiences and show them from any perspective, therefore we no longer have to rely on people's imagination, and we can create experiences that genuinely show people how it is to be somebody else. Due to its characteristics, it gives us the opportunity to experience the life of another person and understand another point of view (Ventura et al., 2020).

In the past few years, big companies and institutions have been making VR 360 degrees films from charities like the International Rescue Committee (IRC) (2017) and Amnesty International (2017) immersing people in the world of a refugee camp in Lebanon and Syria. Moreover, the United Nations currently run a program called "United Nations Virtual Reality (UNVR)", which is implemented by the UN SDG Action Campaign and uses the power of immersive storytelling to inspire viewers toward increased empathy, action and positive social change (2019). Additionally, HTC (2019) and Facebook (Durbin, 2017) have programs using VR technologies in order to promote empathy and social welfare, called "VR for Impact" and "VR for Good" accordingly.

A study by Cummings, Tsay-Vogel, Cahill & Zhang (2021) investigated how dimensions of psychological presence; perceived self-location, sense of copresence, and judgments of social realism can mediate the effect of immersion on cognitive, affective, and associative empathy. Results shows that experiencing a news story via 360° video on a head-mounted display led to stronger self-location and copresence than engaging with the same video via desktop or reading a text version.

Hamilton-Giachritsis et al. in 2018 used virtual reality to place parents in the position of a 4-year-old child from a first-person perspective, with virtual and real body movement synchronization in order to assess its impact on perspective-taking and empathy. They interacted with an avatar of a "mother" who responded either in a positive or a negative way. Results showed that participants reported a strong body ownership illusion for the child body which led to cognitive, emotional, and physical reactions. Experiencing negative maternal behavior increased levels of empathy. In addition, the negative

mother led to increased feelings of fear of violence and physiological data indicated greater stress in the negative than positive condition.

In a similar study, Ahn et al., 2016 showed that embodying animals (e.g., a cow going to the slaughterhouse or a coral suffering the effects of ocean acidification) led to higher self- nature overlap when participants performed a VR perspective taking task rather than just watching a video.

Roswell et al. (2020), piloted a VR experience including racism content to 112 health professionals, faculty and staff of the Zucker School of Medicine and Northwell Health. They experienced a 1-hour interactive large group session and alone, a 20-minute module. A group briefing followed. Results showed that 90.8% of the 76 people who completed the post-workshop survey, felt engaged in the VR experience, and 94.7% of them agreed that VR was an effective tool for enhancing empathy. A large 85.5% of them reported that the session increased their empathy for racial minorities and 67.1% of them that their approach to communication would change.

Schutte and Stilinovićs' study (2017), randomly assigned participants to two groups. One group viewed a documentary featuring a young girl living in a refugee camp in a virtual reality format. The second group, the control group, viewed it in a two-dimensional format. Results indicated that the VR experience resulted in greater engagement and a higher level of empathy for the refugee girl compared to the control condition.

Bertrand et al.'s (2018) study, highlighted immersive embodied virtual reality (EVR) strategies for empathy. Their strategies included the Body ownership illusion through multisensory and motor perspective taking, which, when induced, could modulate bias, mimicry, similarity, and emotion after the experience. Also, the agency illusion, through the embodiment that was combining voluntary and involuntary actions, could result in the self-attribution of the avatar's actions. Another strategy was place and plausibility illusion through sensorimotor stimuli and a highly credible environment, which could result in the users behaving and feeling as if they were in the VR environment. Lastly, they mentioned the Proteus Effect (Yee and Bailenson, 2007; Yee et al., 2009) through avatars presenting empathy-related traits and appearances for the reinforcement of positive or negative stereotypes and the modulation of behavior after the experience. It has been shown that the Proteus effect is mediated by the level of embodiment felt by

the users in relation to their avatar (Ash, 2016) suggesting that EVR can enhance this effect. Bertrand et al. (2018) argue that empathy training methods using avatars designed to improve empathy could induce beneficial behavioral changes and improve positive perceptions. They suggested the embodiment of a digital avatar of an outgroup member, who presents traits that contradict stereotypes, just like we have done in this thesis in studies 1 and 2.

2.3.2 Virtual Reality perspective-taking

Traditionally, novelists and moviemakers through the years have been transporting people into other people's lives and minds with their works. Traditional perspective taking tasks rely heavily on imagination, which means that people can bring their preconceived biases and stereotypes into the experience and not be able to imagine truly, how it is to become somebody else.

The fact that traditional perspective taking tasks rely mainly on imagination means that people doing that have to focus on creating a narrative in their minds and imagine how somebody else's experience is like. But with VR we can simply create a narrative that unfolds around them and therefore they can focus on what is happening around them and how that makes them feel to go through a more genuine experience of what it is like to be that person.

Unlike traditional media, the high level of immersion, the feeling of presence, and the ability to vividly experience any situation from any perspective may uniquely position VR as an effective perspective-taking medium. VR allows users to move their perspectives to different scenarios and universes. One can furthermore play different roles from the perspective of different avatars. The ability of immersive VR to displace the first-person point of view relates directly to perspective taking and role playing.

The use of immersive virtual environments to have an individual take on the perspective of another individual is known as Virtual Reality Perspective-Taking (VRPT) (van Loon, 2018). VR can be a powerful tool in the research of empathy and prejudice because it can transfer you to another world and change your sense of self, as it has been called the "ultimate empathy machine" (Milk, 2015).

An overview of research about VR for inducing empathy and reducing prejudice toward stigmatized groups and the measurements used in the studies was made in 2017 by Christofi and Michael-Grigoriou and is discussed more in the subsection below.

2.3.2.1 VRPT interventions regarding stigmatized groups

This subsection includes the survey that was conducted in order to give an up-to-date overview of research about VR for inducing empathy and reducing prejudice toward stigmatized groups. It was used to identify areas that were not researched and guide the areas of focus of the studies regarding affective attitudes, which ended up being drug users.

Penn et al. in 2010 conducted a 4-condition, between subjects' experiment (N=112), wherein participants were exposed to either a virtual simulation of schizophrenia, a written empathy-set induction of schizophrenia, a combination of both the simulation and written empathy conditions, or a control condition. The results indicated that the virtual simulation + empathy condition induced greater empathy and more positive perceptions toward people suffering from schizophrenia than the control or written empathy-set condition. The simulation-only condition resulted in the greatest desire for social distance whereas not significantly differing on empathy and attitude measures from either the written empathy or simulation + empathy conditions.

It has been shown by several studies (Hasler, Spanlang & Slater, 2017; Farmer, H., Tajadura-Jiménez, A., & Tsakiris, M, 2012; Maister et al., 2013; Peck et al. 2013; Groom, Bailenson & Nass, 2009; Behm-Morawitz, Pennell & Speno, 2016) that embodiment of light-skinned participants in a dark-skinned virtual body significantly reduced implicit racial bias against dark-skinned people.

Hasler, Spanlang and Slater in 2017 studied "in-group bias" and mimicry behaviors. More specifically, they carried out an experiment with 32 White (Caucasian) female participants. Half of them were embodied in a White virtual body and the remainder in a Black virtual body. Each interacted in two different sessions with a White and a Black virtual character, in counterbalanced order. Their results showed that dyads with the same virtual body skin color expressed greater mimicry than those of a different color. Although their study didn't focus on inducing empathy to the participants, they measured the participants' racial bias before and after the experiment. They found that

there was no change in implicit racial bias, as measured by the IAT, simply as a result of the embodiment, i.e., the mean changes are the same whether the participants were embodied in the White or Black body.

Farmer, Tajadura-Jiménez and Tsakiris in 2012 conducted a study in which results from two studies using introspective, behavioral and physiological methods show that, following synchronous visuotactile (VT) stimulation, participants can experience body-ownership over hands that seem to belong to a different racial group. Also, the overall strength of experienced body-ownership seemed to predict the participants' post-illusion implicit racial bias.

Maister, Sebanz, Knoblich and Tsakiris in their 2013 study, they employed the "Rubber Hand Illusion" in light-skinned Caucasian participants, to induce the feeling that a dark-skinned hand was belonging to them. Results showed that the more the participants felt that the dark-skinned hand belonged to them, the more their implicit racial attitudes became.

Peck, Seinfeld, Aglioti and Slater in 2013 showed that the embodiment of light-skinned participants in a dark-skinned VB (virtual body) significantly reduced implicit racial bias against dark skinned people, in contrast to the embodiment in light-skinned, purple-skinned or with no VB. Their results show that embodiment may change negative interpersonal attitudes and thus represent a powerful tool for exploring such fundamental psychological and societal phenomena.

Groom, Bailenson and Nass in their 2009 study examined if the race of people's avatars in a virtual environment can affect their implicit racial bias. Results showed that people that were embodied in a Black avatar, demonstrated greater implicit racial bias outside the virtual environment than people that were embodied in a White avatar.

Behm-Morawitz, Pennell and Gerding Speno in their 2016 research experimentally examined the effectiveness of the use of virtual racial embodiment in a digital gaming application for reducing bias against a non-dominant group. Results showed that creating and embodying a Black avatar produced more favorable beliefs about African American men, but not African American women, and greater support for "pro-minority" policies in comparison to creating and playing a White avatar.

Steed et al. in 2018 created a virtual reality scenario called “We Wait” that gave people an immersive experience of the plight of refugees waiting to be picked up by a boat on a shore in Turkey to be illegally taken to Europe, crossing a dangerous stretch of the sea. They studied the level of presence that might be experienced by participants and the extent to which the scenario might prompt participants to follow-up further information about the refugee crisis, which meant whether or not (and if yes, when) participants accessed a web page that had further information about the refugee crisis after the experiment. Overall, the levels of presence (Place Illusion and Plausibility) were found high (comparable with past findings). Regarding the number of web visits, only 25% of participants visited a relevant web page.

In the study of Roel Lesur, Lyn, and Lenggenhager, (2020), participants embodied a transgender man who was narrating his life. Using an artistic context, they compared VR and elaborate sensorimotor stimulation to a more conventional, mostly audiovisual VR experience. They wanted to study how these would affect embodiment and the perception of this transgender man through an implicit association test and a questionnaire. They did not find any differences in embodiment or implicit or explicit bias, due to the initially low bias in the group.

2.3.3 Virtual Reality for increasing knowledge and explicit attitudes

In this subsection, there are some highlighted examples of studies in which VR was used to change cognitive attitudes like knowledge and explicit attitudes over an entity.

A book chapter was written highlighting VR’s advantages in education and learning. It also examined challenges and problems that need to be considered when integrating VR in training scenarios (Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou & Lanitis, 2019b). Two VR applications were presented as well to showcase VR’s abilities. It was noted that it is not only necessary to reduce the cost of the technology, but the design and development of the activity and educational content need to be facilitated, so that social professionals like teachers, no matter their specialist knowledge, to be able to easily create VR applications. It was concluded that more research needs to be done in order to understand how to exploit the benefits of VR in the learning process.

A research comparing an immersive VR human anatomy application with traditional slide presentations, it was found that although both methods increased participants’

performance, this was higher for participants in the slide-presentation group (Michael-Grigoriou, Yiannakou & Christofi, 2017). In a similar research by Codd and Choudhury (2011) evaluated the use of 3D virtual reality when compared with traditional anatomy teaching methods. They used a "control" group with no prior knowledge of forearm anatomy, a "traditional" group which was taught by textbooks and a "model" group which was taught solely by the e-resource, which was a 3D model of a forearm anterior compartment musculoskeletal anatomy. This model was created using the open-source 3D software "Blender." Findings showed that the model group mean test score was significantly higher than the control but not significantly different to the traditional methods group.

Crosier, Cobb and Wilson (2000) evaluated and compared the use of VR to teach radioactivity directly to the traditional teaching methods used in a school. No obvious benefits were found for the use of VR over traditional teaching methods (TTM) both in terms of test scores and attitude ratings.

Allcoat & von Mühlenen (2018) examined the effects of using VR headsets for learning. For this cause, they compared a traditional (textbook style), VR and video (a passive control) methods of the same learning material. Each participant was given a knowledge test before and after learning. Overall, participants in both the VR and the textbook-style conditions showed better learning than participants in the video condition.

Educators in travel and tourism fields have also begun to explore the potential of virtual learning in platforms like Second Life and take advantage of its effective virtual environment to obtain best results in the learning process (Huang et. al, 2013). The promotion and education about our Cultural Heritage (CH) sites can be achieved with the support of modern technologies like VR.

Tussyadiah, Wang, & Jia (2017) and Tussyadiah, Wang, Jung, & tom Dieck, (2018) conducted 2 studies toward the understanding of how a VR experience could influence people's travel decision making and its impact on attitudes toward tourism destinations. First, the feeling of being in the virtual environment increases the enjoyment of VR experiences. Second, the heightened feeling of being there results in stronger liking and preference in the destination. Third, positive attitude change leads to a higher level of visitation intention. Therefore, this study provides empirical evidence to confirm the effectiveness of VR in shaping consumers' attitude and behavior.

According to Roussou (2002), in order to be suitable for learning, cultural heritage virtual worlds should not just be visually represented in a photorealistic manner; they need to be complete, interactive and present the virtual world in a meaningful and engaging way. The suitability of VR for learning about archeology and the past in CH settings was investigated in a study by Tost and Economou (2009) and results confirmed that VR systems allow a different kind of learning but also questioned the common believe about their advantage for children in comparison with other interpretation methods.

In the study of Pappa, Ioannou, Christofi, & Lanitis (2018), a dedicated VR application was developed that aimed to provide knowledge about the culture of different European countries and raising student's awareness regarding the cultural heritage of the European Union, prior to their mobility period. The comparison of pre- and post- test results pinpoints the positive learning outcomes of the applications on participants indicating in that way the potential of using immersive applications for cultural education.

Ahn, Le & Bailenson in 2013 conducted three experiments that explored whether embodied experiences via Immersive Virtual Environment Technology (IVET) would elicit greater self- other merging, favorable attitudes, and helping toward persons with disabilities compared to traditional perspective taking. Participants in the embodied experiences (EE) condition were exposed to a red-green colorblind simulation using IVET while participants in the perspective taking (PT) condition were exposed to a normal colored IVET world and instructed to imagine being colorblind. The three experiments compared EE against PT and investigated underlying mechanisms. With EE, the user was able to vividly, accurately, and realistically experience the sensations of another person and feel as if they have merged with that person.

Herrera et al. in 2018 conducted two experiments to compare the short and long-term effects of a traditional perspective-taking task and a VR perspective-taking task (Study 1) and to explore the role of technological immersion when it comes to different types of mediated perspective-taking tasks (Study 2), relating to the homeless. Their overall results showed that participants who completed a VR perspective-taking task had more positive attitudes and signed a petition supporting helpful initiatives toward the homeless at significantly higher rates than the participants who just imagined what it

would be like to become homeless or performed a less immersive perspective-taking task. The results of this investigation provide evidence suggesting that VR perspective-taking tasks may be more effective at improving attitudes toward specific social targets and motivating prosocial behaviors in the form of signed petitions in support of helpful initiatives than traditional and less immersive perspective-taking tasks.

Seinfeld et al. in 2018 used VR to allow offenders to virtually embody, in first person perspective, a victim of domestic abuse in order to assess their emotion recognition skills. Findings from this study showed that those offenders had a lower ability to recognize fear in female faces than the control group and reduced their bias toward recognizing fearful faces as happy.

Bujić, Salminen, Macey & Hamari (2020) investigated how media content consumed through immersive technology, or in their case "Immersive Journalism" may evoke changes in human rights attitudes. Their participants viewed a 360-degree video via VR, 2D and article formats. Their findings indicate a positive attitude change in the VR group, unlike the article group. VR had a better effect than the 2D screen.

2.4 Conclusions

This chapter, regarding the background knowledge, took a deep dive in VR, its definition, uses, key concepts and why it is a technology worth considering in attitude change. According to the literature, VR is used in many contexts regarding changing both affective and cognitive attitudes.

Regarding affective attitudes, outcomes from the studies reviewed in the survey (Christofi & Michael-Grigoriou, 2017) provided preliminary support for the use of VR for successfully inducing empathy toward stigmatized groups. Changing people's attitudes and institutional practices is a hard but necessary work. Researchers have found that perspective-taking induces empathy which, in turn, not only improves attitudes toward the target of empathy but also improves attitudes toward the target's group. Below, there is a table summarizing the studies conducted for the use of VR to induce empathy toward stigmatized groups (Table 1).

Table 1: Overview of VR studies for empathy for stigmatized groups

Study reference	Stigmatized group	Groups	Outcome
Penn et al. in 2010	People suffering from schizophrenia	-Virtual simulation of schizophrenia -Written empathy-set induction of schizophrenia -Combination of both the simulation and written empathy conditions -Control condition	The virtual simulation + empathy condition induced greater empathy and more positive perceptions toward people suffering from schizophrenia than the control or written empathy-set condition
Hasler, Spanlang and Slater, 2017	Dark-skinned people	-White virtual body -Black virtual body	No change in implicit racial bias, as a result of the embodiment
Peck, Seinfeld, Aglioti and Slater, 2013	Dark-skinned people	-Dark skinned virtual body - Light-skinned virtual body - No virtual body	Embodiment of light-skinned participants in a dark-skinned virtual body significantly reduced implicit racial bias against dark skinned people, in contrast to the embodiment in light-skinned, purple-skinned or with no virtual body

Behm-Morawitz, Pennell and Gerding Speno in their 2016	Dark-skinned people	-White avatar -Black avatar	Creating and embodying a Black avatar produced more favorable beliefs about African American men, and greater support for "pro-minority" policies
Roel Lesur, Lyn, and Lenggenhager, 2020	LGBTQ	-VR with sensorimotor simulation -Audio-visual VR	No differences in embodiment or implicit or explicit bias
Schutte and Stilinovićs, 2017	Refugees	-VR documentary -2D-format	VR experience resulted in greater engagement and a higher level of empathy for the refugee girl
Herrera et al., 2018	Homeless	1) Written information 2) Narrative-based perspective-taking 3) Desktop 4) VRPT	Participants who completed a VR perspective-taking task had more positive attitudes and signed a petition supporting helpful initiatives toward the homeless
Seinfeld et al., 2018	Domestic violence offenders	-Control -Offenders	Offenders had a lower ability to

			recognize fear in female faces than the control group and reduced their bias toward recognizing fearful faces as happy

Regarding cognitive attitudes and more specifically knowledge, a book chapter was written highlighting VR's advantages in education and learning. It also examined challenges and problems that need to be considered when integrating VR in training scenarios (Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou & Lanitis, 2019b). It was noted that it is not only necessary to reduce the cost of the technology, but the design and development of the activity and educational content need to be facilitated, so that social professionals like teachers, no matter their specialist knowledge, to be able to easily create VR applications. It was concluded that more research needs to be done in order to understand how to exploit the benefits of VR in the learning process.

As technology is evolving and VR is being on its rise as well, nowadays, the transformative power that VR has can make us as close as we can be to "walk a mile in someone's shoes". This can be a powerful tool in understanding other people's perspectives, be empathetic toward them. VR has also the potential to make learning more engaging and fun and more effective than traditional methods used in schools nowadays.

This dissertation will aim to examine in more detail how VR can affect affective attitudes like empathy for drug users and cognitive attitudes like knowledge for archaeological sites.

3 Methodological framework

Chapter 2 took a deep dive into the existing literature and the most essential concepts in this dissertation. It helped to identify the gaps in the literature and where and how the studies conducted can help. This chapter presents the chosen research design for the individual studies, and more specific topics, like the way the participants were recruited, how data was collected and the ethical considerations.

Our aim in this thesis was to investigate the use of VR in attitude change to modernize and make more engaging the existing methods used by social professionals. As mentioned in Chapter 2.1.2, attitudes can include emotions toward an entity, behavior or knowledge and beliefs toward it.

According to the aim of each of the studies, different dependent variables will be used, which the effect of VR will be examined on them. The proper method for this kind of research is Experimental Research as it is used “when a researcher wishes to trace cause-and-effect relationships between defined variables” Tanner (2018).

3.1 Identifying the problem and target groups - Literature review

The problem and objectives needed to be identified as a first step. This was achieved by doing a review of the literature and identifying the gap.

3.1.1 Affective attitudes

Regarding affective attitudes and more specifically empathy, a survey was conducted (Christofi & Michael-Grigoriou, 2017), focusing on studies related to VR applications that their aim was to induce empathy and reduce prejudice toward stigmatized groups.

Results of this survey showcased that most studies dealt with people with a disability, homeless people, and most of them had a focus on reducing implicit racial bias against dark-skinned people. Findings helped with deciding the focus group of the experiments, which was drug users, as it was apparent that there was a lack of studies dealing with them in this context of changing attitudes toward them.

3.1.2 Cognitive attitudes

Regarding cognitive attitudes and more specifically knowledge, a book chapter was written highlighting VR's advantages in education and learning. It also examined challenges and problems that need to be considered when integrating VR in training scenarios (Stavroulia, Christofi, Zarraonandia, Michael-Grigoriou & Lanitis, 2019b).

Two VR applications were presented as well to showcase VR's abilities. It was noted that it is not only necessary to reduce the cost of the technology, but the design and development of the activity and educational content need to be facilitated, so that social professionals like teachers, no matter their specialist knowledge, to be able to easily create VR applications. It was concluded that more research needs to be done in order to understand how to exploit the benefits of VR in the learning process.

3.2 Planning the studies

For Study 1, we wanted to investigate whether different perspectives can change the affective attitudes of teachers toward drug users in a school through a virtual school environment. So, we created three different perspectives; (a) Teacher, (b) Student-drug user, (c) Observer student. Participants, who were all either in-service or pre-service teachers, were randomly assigned to two groups; (i) Participants viewed the Teacher + Observer student perspective of the incident and (ii) Participants viewed the Teacher + Student-drug user perspective of the incident.

In Study 2, we wanted to investigate whether sensorimotor contingencies supported by a VR system, can change the affective attitudes induced toward drug users. Participants were randomly assigned to one of two groups; (i) VR group that offered sensorimotor contingencies and (ii) Non-VR group which did not offer sensorimotor contingencies and viewed the application through a Desktop computer.

In Study 3, we wanted to investigate whether the use of a VR-based simulation can change peoples' cognitive attitudes about an archaeological site. Participants were randomly assigned to one of two groups; (i) VR group, (ii) Desktop group.

In the table below, there is an overview of the design of the three studies (Table 2).

Table 2: Overview of the design of the three studies

Study 1	
Problem	Teachers lack empathy in substance related issues in schools.
Scenario	Substance use incident involving students in a school area.
Research questions	Do different perspectives change the affective attitudes of teachers toward drug users in a school through a virtual school environment?
Study 2	
Problem	People think that drug users are "bad" and lack empathy toward them.
Scenario	Life of a person who becomes a drug user.
Research questions	Do sensorimotor contingencies supported by a VR system, change the affective attitudes induced toward drug users?
Study 3	
Problem	Learning methods about cultural heritage are outdated and often not engaging.
Scenario	VR Archeological tour of a site.
Research questions	Can the use of a VR-based simulation change peoples' cognitive attitudes about an archaeological site?

3.3 Design of scenarios

This phase aimed to create three different scenarios. Two of them relate to drug users, one in a school area, and the other as a narrative showcasing the life of a person who becomes a drug user, and the consequences on his work life and relationship. The last scenario relates to cultural heritage.

The first scenario was inspired by a real incident that took place in a school and has to do with the use of substances given to a student by his classmates during the break.

A detailed description of the scenario is presented in Chapter 4.

The second scenario deals with a man, engaged, who recently lost his mother from cancer and whose depression and anxiety from work led him to try out cocaine at a party, which he attended after an invitation from a coworker, and the consequences of the drug on his body, face, work and relationship.
The last scenario deals with a virtual archaeological tour of a site, aimed at increasing people knowledge about the site, through audio clips placed around the site, and changing peoples' attitudes toward archaeology and cultural heritage.

3.4 Design and implementation of the VR application

Following the scenarios that were designed, the corresponding VR applications had to be developed. For this cause, Unity software was used for the development of the virtual worlds. Regarding the integration of VR in the applications, the Oculus plugins were used and relevant scripts using the C# scripting language.

For Study 1, we used additionally the Microsoft Kinect v2 for real time full body motion tracking, a Fitbit charge 2 fitness watch for recording the participants' heart rate during the experiment and the EMOTIV EPOC+ EEG device for measuring the brain waves. We recorded the dialogues of the students using real people and a Philips recorder. We used the SALSA plugin in Unity, for the avatar's eye movements and lip synchronization with the dialogues for a more realistic approach and MIXAMO for the avatar's body animations.

For Study 2 we used the Xsens motion capture motion capture recordings from real people and MIXAMO for the avatar's body animations. We used recordings for the dialogues.

For Study 3 we used an Xbox controller for the movement in the virtual archaeological site, and key frame animations for the rotation of the information points in the world that the user could interact with, to listen to audio recordings including information about the place they were standing at.

Below is a table listing all the elements that were used in all three studies grouped in a table (Table 3).

Table 3: An overview of the materials of the three studies

	Study 1	Study 2	Study 3
Target audience	In-service and Pre-service teachers	Everyone (over 18 years old)	Everyone (over 18 years old)
VR headset	Oculus CV 1	Oculus CV 1	Oculus CV 1
Extra equipment	-Kinect v2 -EMOTIV EPOC+ EEG device -Fitbit charge 2 fitness watch	-Xsens motion capture suit -ManusVR gloves	Xbox controller
Game engine	Unity software	Unity software	Unity software
Visual elements	Canvas for UI (dialogues)	No UI	Canvas for UI
Sound	Recorded dialogues	Music, sound effects, recorded dialogues	Audio recordings
Interaction	Low interaction with Oculus Touch controller to move the dialogue	-No interaction in the VR group. -Mouse input to move camera in non-VR group	-Controller for movement -Interaction with information points
Animations	-Mixamo -Salsa plugin for eye and mouth movements	-Mixamo -Xsens motion capture system -Salsa plugin for eye and mouth movements	Scripted-based for the rotation of information points
Platform	PC	PC	PC

3.5 Data collection and analysis of data

The studies in this thesis followed the between subject's design.

Participants were randomly assigned to either the control group, which in studies 1 and 3 is a non-VR group, or the experimental group which in all 3 studies includes a VR group. The goal of the experiments will be to determine the differences between these two groups. Quantitative data will be collected with the use of various questionnaires.

After the experiments and the collection of all the data, this data was analyzed in the SPSS software. Different tests like correlations and differences between the studied groups, factor analyses on groups of variables and t-tests were applied.

An overview of the three studies can be found in the table below (Table 4).

Table 4: Overview of the three studies

	Study 1	**Study 2**	**Study 3**
Scenario	Substance use incident involving students in a school area	Life of a person who becomes a drug user	VR Archeological tour of a site
Groups	3 VR Perspectives: Perspective I: Teacher Perspective II: Student Drug User Perspective III: Healthy Student	VR group Non-VR group	VR group Non-VR group
Sampling technique	Snowball	Convenience /volunteer	Convenience/volunteer
Sample	25 participants Group 1: 12 participants Group 2: 13 participants	40 participants VR group: 20 participants Non-VR group:	40 participants VR group: 20 participants Non-VR group: 20

		20 participants	participants
Instruments	- Questionnaires -EEG device (EMOTIV EPOC+ 14 Channel Mobile Brainwear) -Fitness wristband Fitbit charge 2	-Questionnaires	-Questionnaires

3.6 Recruiting participants and ethics

For the recruitment of participants for the studies in this dissertation, convenience sampling was mainly used alongside snowball sampling.

For the first study, we recruited several teachers from a local middle school as well as people with teaching experience. Snowball sampling was used, as it is appropriate in populations that researchers have difficult access to. The snowball sampling refers to the technique in which existing participants recruit future participants from their acquaintances and in this case, colleagues too (Sharma, 2017). As teachers have interaction daily with other teachers, this technique was considered to be the most appropriate. Snowball sampling comes with disadvantages too, as it is not based on random selection anymore, so it would be impossible to generalize about the population.

Concerning the remaining studies, for the recruitment, social media posts and emails within the university were circulated, calling for people over 18 years old to participate in the study.

It is important to note that all participants provided their written informed consent to participate in the experiments. All participants, in all three studies, were over the age of 18. Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in the respective article. None of the participants had prior knowledge regarding the objective of the studies.

4 Study 1 – Changing the affective attitudes of teachers for drug users in schools

4.1 Introduction and Objective

This chapter focuses on the first study that was conducted for this dissertation.

A systematic review of empirical studies by Freeman et al. (2017), regarding VR in the assessment, understanding, and treatment of mental health disorders, found 22 studies for substance-related disorders, with 15 concerning assessment, five treatment, and two theory development. A big majority of those studies showed that appropriate VR environments can trigger cravings.

Substance use is not only a major societal concern, but also a serious problem within the school environment. Teachers need to be able to understand student's disorders including problems such as drug use disorders. The use of VR can provide to a target group, like teachers in this case, a safe environment with real-life based scenarios to allow them to understand in depth student's disorders by seeing events from different perspectives. Such exposure, taking advantage of VR technology and offering the possibility to experience situations from another person's perspective, will maximize teacher's professional development and cultivations of skills such as empathy (Batson, 2009).

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, 2002). 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.

Teachers need to act, become more sensitive and deal responsively with students experiencing these disorders. The first step for changing teachers' attitude toward the problem and at the same time cultivating empathy toward problematic students, is to put them in the position of the student facing the problem, in an effort to make them understand them.

Thus, the first study of the dissertation (Christofi et al., 2018, Stavroulia et al., 2018, Stavroulia et al., 2019a, Christofi et al. 2021), by using VR based methodology, allowed teachers to put themselves in the position of a student that faces substance use problems in the school environment, in order to understand them and change their affective attitudes, and more specifically empathy toward the drug user in the scenario they experienced.

4.2 The scenario

The scenario was inspired on a real incident that took place in in a school in Cyprus. The scenario that was written for this experiment takes place in the school outdoors space during break time (Figure 2). A student (named Anna) is watching her classmate (Nikos), who is sitting on a bench, having done substance use, and is having delusions and hallucinations as a result of it. Anna is trying to find out by asking another classmate (Kostas) what has happened to Nikos and after revealing the drug use, Kostas is trying to pressure Anna to smoke a cannabis cigarette.

Figure 2: The school environment that was used for the application.

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).

You find the complete scenario with the dialogues in Appendix A-1.

4.3 Groups and perspectives

In this section, we describe the experimental setup used as the basis of our investigation that aims to assess the suitability of VR for changing teachers' attitudes and understanding toward the substance use problem in schools and cultivating empathetic skills. A between-group design experiment was conducted for this study. The 25 participants that were recruited, were divided into two groups according to the two perspectives they witnessed in the virtual world. They were three perspectives in total:

- Perspective I: Teacher perspective (TP) (Figure 3)
- Perspective II: Student-Drug User perspective (SDUP) (Figure 4)
- Perspective III: Student-Observer perspective (SOP) (Figure 5)

Figure 3: A view from the Teachers' perspective (TP).

Figure 4: A view from the Student's drug user perspective (SDUP).

Figure 5: A view from the Student-Observer Perspective (SOP).

The two groups were:

- **TSDU group (Teacher - Student Drug User):** The participants experienced firstly the teacher's perspective and then experienced the same scenario through the eyes of the student drug user.
- **TSO group (Teacher - Student Observer):** The participants experienced firstly the teacher's perspective and then they entered the virtual body of the student observer Anna.

The two groups and the perspectives participants experienced are presented in Figure 6 below.

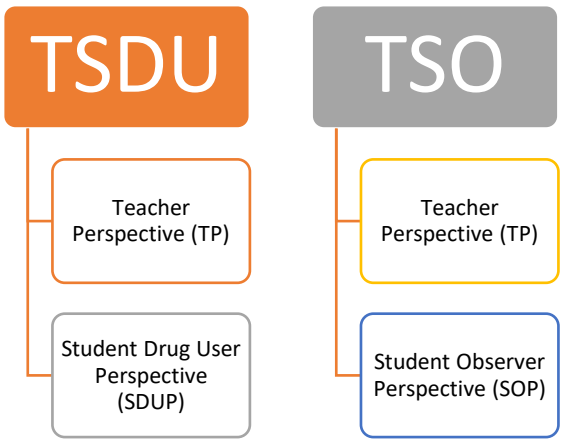


Figure 6: The 2 groups and their perspectives

Both groups viewed the teacher's perspective of the drug incident in the school environment. In each perspective, the participants were observing the scenario through the eyes of their avatar (first-person perspective - 1PP) (Figure 7).

Figure 7: The camera position is at the avatar's eyes height, for 1PP.

Their body and head movements were mapped in real time to the virtual body (they were tracked by specialized equipment, the motion-sensing device Microsoft Kinect for Windows v2), seen both by looking directly down at their real body and in the virtual mirror which was located in front of them at the beginning of each perspective.

4.4 Application design and development

4.4.1 The avatars of the scenario

All participants, despite the Group they were assigned, experienced the perspective of the teacher in the beginning. The avatar of the teacher is seen in Figure 8 (left).

Participants in the TSO group had the opportunity to view the scenario from the eyes of a student observer of the whole scenario, named Anna. Her avatar can be seen in Figure 8 (middle). The avatar of the student (Kostas) who is trying to pressure Anna to smoke a cannabis cigarette is seen in Figure 8 (right).

Figure 8: The avatars of the teacher (left), student-observer (middle) and the student who offers drugs to the student-observer in the scenario (right).

Participants in the TSDU group "took the perspective" of the drugged student (Figure 9, left) so that they virtually "experience" the effects of this drug. For this purpose, motion blur was added to the virtual camera and the colours were made brighter using filters in the Unity software (this was done because marijuana may cause head rush or dizziness and heightened sensory perception) (Thomas et al., 2014, National Institute on Drug Abuse, 2018).

Figure 9: The avatar of the drugged student (left), and a close up of his red eyes (right).

Additionally, the eyes of the avatar of the drugged student were coloured red (Figure 9, right), (by changing the color in the avatars UV texture), which is one of the most noticeable effects of smoking marijuana (MedWell Health and Wellness Centers, 2016). Lastly, the audio files of the dialogues were modified (by lowering the pitch and adding echo effects in the Adobe Audition software) and the font of the speech bubbles' text that was appearing next to the person that was talking was changed so that the words were not easily readable. A video showing all three character perspectives can be found at this link: https://youtu.be/PpylENYifYg.

4.4.2 VR application development

4.4.2.1 Mirror training for familiarization

At the beginning of each scene, a mirror was in front of the position of the avatar, so as for the participants to perceive and become familiar with their virtual body and environment (Figure 10). The participant's full body (body and head) movements were mapped in real-time to their virtual body. The movements were tracked real time using the motion-sensing device Microsoft Kinect for Windows v2.

The participants were able to look at their virtual body, both by looking directly down and by looking in the mirror that was located in front of them. The participants were told that they could spend as much time they needed in the mirror scene to become familiar with their virtual body. The mirror training aimed to familiarize the users with their non-physical body (avatar), identify with the virtual body, and feel in control of it. This process was necessary to achieve participants' sense of embodiment. The mirror training was the initial point for every scene and each perspective.

Figure 10: A virtual mirror in which the participants could see their virtual self as the teacher (top), the drugged student (middle), and the student-observer (bottom).

4.4.2.2 Materials and technical setup

The VR system that was used for the experiment included the Head Mounted Display (HMD) Oculus Rift CV which was coupled with a positional tracker. The physical movements of the participants were tracked using the motion sensing device Kinect for Windows v2 and mirrored to the avatar they were controlling in the virtual world. The desktop computer used was equipped with an NVidia GeForce GTX 1070 graphics card and 16GB RAM. In order to proceed through the dialogues in the virtual world, the participants used the Oculus Remote that they were holding in one of their hands (Figure 11).

The VR application was developed with the Unity software game engine. The 3D avatars (teachers and students) were created using the online software Autodesk Character Generator, in which a skeleton was also added to the models as well as facial blend shapes so that their mouths could move according to the dialogues recorded. The voice lines of the dialogues of the scenario of the application were recorded using a

Philips digital recorder and edited in the software Adobe Audition CS6. It is important to note that the voices were recorded by real students so that to provide a more realistic, believable, and authentic experience to the participants.

Additionally, 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 the recording of the brain signals. The EPOC+ has saline based wet EEG sensors, it can wirelessly connect to PC and mobile devices, and it is rechargeable with 9 axis motion sensors. It transmits wireless data at 128 or 256 Hz.

Figure 11: Two participants during the experiment, wearing the Oculus Rift and holding the Oculus Remote.

4.5 The procedure

The participants took part in the experiment, one at a time. At first, they had to read and sign a consent form of the study very carefully before participating in the research study. Afterward, they had to fill the pre-questionnaire which included demographic questions and questions related to their mood states and empathy. Representative questions of this questionnaire are shown at the Table 5.

After the completion of the pre-questionnaire, the EEG device and the EMOTIV EPOC+ was fitted on the participants along with the Oculus Rift CV (see Figure 12). Moreover, the participants had to wear the wristband to their hand. During this fitting process, the participants were also informed about the scenario and the two perspectives that they would experience, while information was also provided regarding the way to interact within the virtual world, which was to press the button on the Oculus Remote, to make the scenario proceed at their own pace. When the fitting was done, participants were asked to stand in a small distance directly in front of the Microsoft Kinect device. Then the virtual experience was commenced.

At the beginning of each scene, a mirror was in front of the position of the avatar, so as for the participants to perceive and become familiar with their virtual body and environment. 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 completion of the scenario, the HMD, the EMOTIV EPOC+ and the wristband were taken out and the participants were asked to complete the post-questionnaire which included questions regarding their sense of presence, embodiment, their mood states and empathy. Representative questions of this questionnaire are shown at the Table 5.

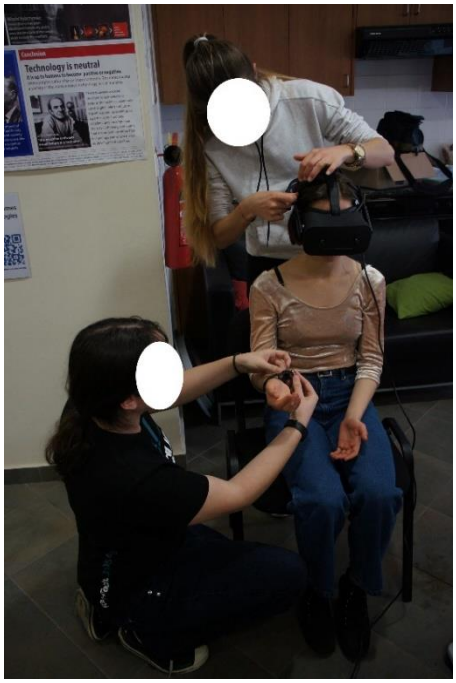


Figure 12: Fitting the fitness watch and Oculus Rift CV to one of the participants

4.6 The instruments

4.6.1 Questionnaires

A combination of methods was used to acquire the data necessary to answer the research question. Quantitative data were collected using two questionnaires completed before and after the experiment, while heart rate and brain signals were also recorded during the VR experiment.

The pre-questionnaire (Table 5) contained three parts, one for collecting demographic information (country, gender, age, employment status, teaching experience, teaching specialty, experience in using VR technologies), a second part for evaluating teachers' empathy, and a third part aiming to record participants' mood states before the experiment, using a scale based on the Positive and Negative Affect Schedule (PANAS X) scale (Watson, Clark & Tellegen, 1988; Watson, & Clark, 1994). PANAS X consists of several words and phrases that describe different feelings and emotions. The scale has many categorizations, which did not respond to the aims of the current research. Hence, only some of the scale items were used. A few examples of them can be found in Table 5b.

Table 5: Sample of questions in pre and post questionnaires

Sample of measures
Pre Measurements (Sample questions)
a) Empathy
Evaluate the following comments about teachers' abilities
1. When I hear about a drug situation in the news, I immediately feel sad.
2. I try to see things from my student's points of view.
3. I believe that understanding student's drug-related problems make me a better teacher.
b) Mood states

This following scale consists of several words and phrases that describe different feelings and emotions. Indicate to what extent you had any of those feelings during the VR experience.
1. Nervous
2. Fear
3. Relaxed
4. Ashamed
Post Measurements (Sample questions)
c) Presence/Place Illusion
Now you will see some statements about experiences. Please indicate, whether or not each statement applies to your experience.
1. I had a sense of "being there" in the school space…
2. During the experience I often thought that I was really standing in the school space
3. I think of the school space as a place in a way similar to other places that I've been today…
d) *Embodiment*
1. Although the virtual body did not look like me, when I looked at my body I had the sensation that it was mine.
2. The virtual body moved according to my movements.
3. I felt that I controlled the avatar as if it were my body.

Regarding empathy, a mixture of scales was used to develop the scale used in this study. The questions used and the scales they were based on, can be seen in Table 6. The scale consisted of a 6-point Likert scale (Not at all …Completely agree). Sample questions regarding empathy can be found in Table 5a.

Table 6: Empathy scale items.

Empathy items	**Scale it is based on**
When I see someone who is facing drug problems, I often wonder about why they got involved with drugs and consider their situation later in the day.	Existing Teacher Empathy Scale (TES) Bouton & Buxton (2014)
When I hear about a drug situation in the news, I immediately feel sad.	TES
I have volunteered to assist drug users who needed help in some way.	TES
I find it difficult to relate to students going through drug problems.	TES
I try to see things from my student's points of view.	Empathy Questionnaire Research Collaboration (2015) Gaumer Erickson, Soukup, Noonan, & McGurn, (2018).
When I see a student in distress because of drug problems and I am not able to help, I am deeply troubled and revisit the situation many times after the fact.	TES
I believe that understanding student's drug-related problems make me a better teacher.	TES
I have little sympathy for students who face problems such as drug use.	TES
I try to think like drug users in order to better understand them.	TES

It is important for my students to know that I care about them.	TES
I do not feel sympathy for students who cause their own serious illnesses such as drug-related problems.	Toronto Empathy Questionnaire Spreng, McKinnon, Mar & Levine (2009).
Sometimes I wonder what it would feel like to be in my student's situation.	Empathy Questionnaire Research Collaboration (2015)
Sometimes I don't feel very sorry for my students when they are having problems such as drug problems.	IRI – Interpersonal Reactivity Index Davis (1980)
I sometimes find it difficult to see things from the student's point of view.	IRI
Before criticizing a student, I try to imagine how I would feel if I were in their place.	IRI

The post-questionnaire contained three parts, the first part aimed to evaluate participant's sense of presence in the virtual world using Slater-Usoh-Steed Questionnaire (SUS) (Usoh et al., 2000). Sample questions regarding presence can be found in Table 5c.

Six additional questions to measure the level of embodiment they felt inside their virtual body. Sample questions regarding embodiment can be found in Table 5d. The embodiment scale was based on the paper of Hasler et al., (2017).

The second and third part was identical to the pre-questionnaire in order to identify how participant's experience in the virtual world affected empathy and mood states. In Figure 13, there is a graph showing the questionnaires given in the pre- and post-questionnaires.

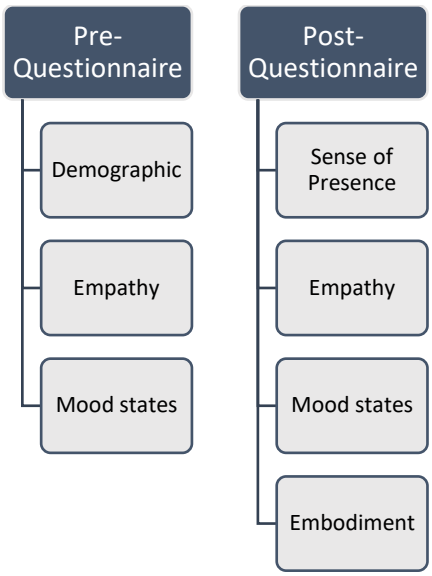


Figure 13: The Pre and Post questionnaires given to the participants.

4.6.2 EEG and Heart Rate monitoring

There are several methods for the recognition of mood states in VR, other than self-report questions, that were used in this study. It is noted that only the collection of this data is part of this thesis.

First of all, skin conductance has been used, as well as heart rate variability (HRV) in order to capture the responses of the autonomic nervous system (Baumgartner, Valko, Esslen, & Jäncke, 2006; Kim, Rosenthal, Zielinski, & Brady, 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). Lastly, EEG has been used in order to capture the brain signal and its possible alterations as well as self-reports (Marin-Morales, Llinares, Guixeres & Alcañiz, 2020; Menezes et al., 2017; Rodríguez, Rey, Clemente, Wrzesien, & Alcañiz, 2015). We recorded separately the three aforementioned perspectives (teacher, user and healthy) and we were focused mainly on the frontal and parietal areas of the brain. It has been proved that parietal area plays an important role in the experience of presence (Kober, Kurzmann & Neuper, 2012; Baka, Stavroulia, Magnenat-Thalmann, & Lanitis, 2018) and can be used as a measure for the validation of its existence.

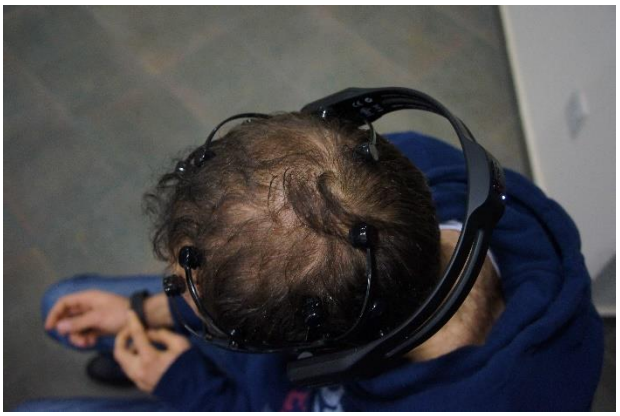


Figure 14: The EEG device used in this experiment

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 intention of the user. The use of this multimodal approach was decided in order to achieve higher reliability of the results based on the outcomes of each instrument.

4.6.3 Participants

A total number of 25 participants (n=25) took part in the experiment, 72% (n=18) female and 28% (n=7) male. 88% of the participants (n=22) were from Cyprus, one participant from Greece, one from Serbia and one from Ukraine. Regarding the perspectives that the participants experienced, 52% experienced the perspective of the teacher and the student drug users and 48% experienced the perspective of the teachers and the student observer. Most of the participants aged from 18 to 39 years old (84%), 8% aged from 40 to 49 and 8% aged from 50-59 years old. The majority of the participants (64%) were active teachers, serving in secondary (36%), higher (24%) and primary education (4%), while 36% of the participants were not currently employed as teachers. Data on participants' demographics and specialty selected revealed a variety of fields including computer science (20%), multimedia and graphic arts (16%), mathematics (12%), literature (12%), foreign languages (8%), primary education, physical education (sports), sociology, speech pathology and web design. Furthermore, data on participants' experience in using VR environments, indicated participant's unfamiliarity with VR, as 36% claimed to have never used VR in the past, 32% claimed to have "a little" experience, 12% claimed to have "moderate" experience, 12 claimed

"much" VR experience and only 8% claimed to be "very much" familiar with the use of VR.

4.7 Results

The data collected were analysed with the use of SPSS software (Statistical Package for Social Sciences), while the EEG data were analysed using MATLAB software and specifically the EEGLAB toolbox. The analysis of the EEG data has been conducted by co-authors of Christofi et al., 2018. The means, standard deviations and the significant difference of the mean between the groups for the outcome variables; dEmpathy, Presence and Embodiment by condition (TSDU and TSO) are summarized in Table 7.

Table 7: Means, and standard deviations and p-values for outcome variables for both groups.

Measures	**Condition**				
	TSDU		**TSO**		**p-values**
	Mean	**SD**	**Mean**	**SD**	
dEmpathy	-0.0119	0.39458	0.0275	0.35179	p = 0.794
Presence	4.1667	1.14134	4.6923	1.04935	p = 0.301
Embodiment	3.1250	0.84125	3.3462	0.63996	p = 0.465

SD=Standard deviation

4.7.1 Presence

This section presents the analysis of the results concerning the presence section items (Table 5). The median score for the TSDU group was 4 out of 7, and 4.0714 out of 7 for the TSO group. There was not a significant difference in the sense of presence of the participants between the two groups, TSDU (M = 4.1667, SD = 1.14134) and TSO (M = 4.6923, SD = 1.04935) conditions; t(23) = -1.058, p = 0.301.

4.7.1.1 Conclusions regarding presence scale

The results suggest that the participants felt moderately the sense of presence as the mean scores and the median tend to be higher in the middle of the scale.

Regarding the impact of the different perspectives that the participants experienced the levels of presence, the results of the questionnaire did not confirm a statistically significant difference. Thus, changing a perspective toward the substance use event during the scenario did not affect participant's levels of presence.

From the data, it can be concluded that presence was achieved as the participants reported that they felt as being part of the virtual school space. Although the reported levels of presence did not reach the maximum score of the Likert scale, it is significant that none of the participants reported the virtual world as images but as a place they visited. One possible factor for the medium levels of presence could be participants' inexperience with the use of VR. Heeter (1992) argues that users' prior experience with the virtual worlds might play a role in presence and suggests that the more familiar the users are with virtual worlds the more likely it is that the sense of presence is increased. Therefore, the unfamiliarity of the sample with virtual worlds could have led to the lower levels of presence. Nevertheless, the VR system provoked participant's sense of presence as the users felt to be inside the virtual school environment.

4.7.2 Embodiment

This section presents the analysis of the results concerning the embodiment section items (Table 5). The median score for the TSDU group was 3.3333 out of 5, and 3.500 out of 5 for the TSO group. There was not a significant difference in the scale of embodiment of the participants between the two groups, TSDU (M = 3.1250, SD = 0.84125) and TSO (M=3.3462, SD=0.63996) conditions; t(23) = -0.743, p = 0.465.

4.7.2.1 Conclusions regarding embodiment scale

The results show that the participants tended to be more neutral regarding the sense of embodiment, no matter their group, according to their median scores.
The researchers noticed during the experiment that the participants, although they were encouraged and instructed during the mirror scene, to look at their virtual body and

spend time to familiarize themselves with it, the participants seemed indifferent and spent only a few seconds doing it. This could have impacted their sense of embodiment. Moreover, since most of the participants were unfamiliar with VR technologies and the terminology used in the questionnaire, perhaps they did not understand fully the questions. Lastly, something else that might have impacted their experience, was the fact that several disconnections of the hardware (Kinect) happened for some of the participants, and the experiment had to restart from the beginning for calibration purposes.

The lack of interactivity could have impacted the results as well. Although participants were able to embody and the teacher and a student, they were simply viewers of the incident in both scenes, not really utilizing the opportunities coming from the embodiment of those avatars.

4.7.3 Empathy

This section presents the analysis of the results concerning the empathy section items.

4.7.3.1 Pre-empathy

The median score for the TSDU group was 4.2500 out of 6, and 4.3571 out of 6 for the TSO group. There was not a significant difference in the scale of pre-empathy of the participants between the two groups, TSDU (M=4.1905, SD=0.39399) and TSO (M=4.3242, SD=0.58729) conditions; t(23) = -0.662, p = 0.514.

This result is positive, as the two groups were balanced in terms of their empathy before their exposure.

4.7.3.2 Post-empathy

The median score for the TSDU group was 4.1429 out of 6, and 4.3571 out of 6 for the TSO group. There was not a significant difference in the post-empathy of the participants between the two groups, TSDU (M=4.1786, SD=0.31579) and TSO (M=4.3516, SD=0.46425) conditions; t(23) = -1.080, p = 0.291.

4.7.3.3 Pre and post differences

Within the TSDU group, there was not a significant difference between the pre and post empathy of the participants, pre-empathy (M=4.1905, SD=0.39399) and post-empathy (M=4.1786, SD=0.31579) conditions; t(11) = 0.105, p = 0.919.

Within the TSO group, there was not a significant difference between the pre and post empathy of the participants, pre-empathy (M=4.3242, SD=0.58729) and post-empathy (M=4.3516, SD=0.46425) conditions; t(12) = -0.282, p = 0.783.

Regarding individual questions, a significant difference was found in the TSDU group, in the question, whose values were reversed for the analysis “I find it difficult to relate with students going through drug problems.”, pre-empathy (M=2.3333, SD=0.98473) and post-empathy (M=3.4167, SD=1.67649) conditions; t(11) = -2.862, p = 0.015.

Regarding the differences between the two groups, a new variable was calculated. The variable of interest, dEmpathy = postEmpathy – preEmpathy, reflects the degree of change in empathy. There was not a significant difference between the two groups, TSDU (M= -0.0119, SD=0.39458) and TSO (M=0.0275, SD=0.35179) conditions; t(23) = -0.264, p = 0.794.

4.7.3.4 Conclusions regarding empathy scale

Results show no difference between the two groups in their empathy. The only significant difference was found in the reversed item “I find it difficult to relate with students going through drug problems” in the TSDU group.
After the end of the experiments, many of the participants of the TSDU group reported to the researchers that they were problematized and admitted that they tend to ignore substance use problems because they do not know how to handle them.
To sum up, although the median scores for both pre and post empathy were above the middle, no significant changes were found either before, neither after the experience between the two groups. So, concerning the possibility to cultivate empathy via using a VR approach, these results are not that strong and further research is needed to determine the effect of VR on empathy skills.

This result could be explained by the lack of interactivity with the application and player choice. Participants could not interact with the other virtual avatars. A future version of the application could include actions for the participants to perform. Such actions could include choices on how to interact as the teacher to the student drug user, so that they actually know how to react and respond to situations like this, as this was missing from the current scenario. Another way is for the participants when they are embodying the student drug user, to get the choice if they will accept the cannabis cigarettes from the other student.

4.7.4 Mood states

This section presents the analysis of the results concerning the mood states section items.

4.7.4.1 Pre-mood states

According to the results, before the VR intervention, no significant differences were found in any of their mood states between the two groups. You can see the means of each pre-mood state for the two groups in Figure 15.

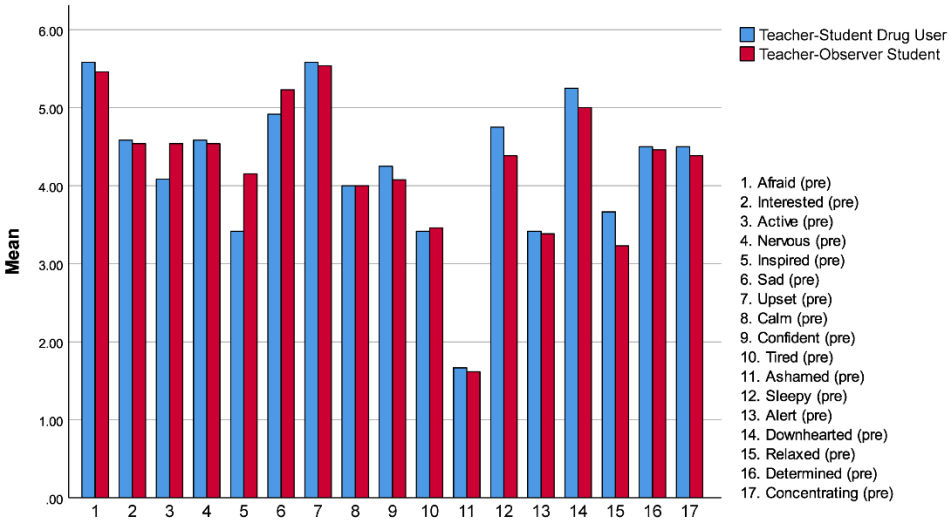


Figure 15: Means of the pre- mood states for the two groups

4.7.4.2 Post-mood states

According to the results, before the VR intervention, a significant difference was found only in the "Downhearted" mood state after the VR experience, TSDU (M=4.4167, SD=1.67649) and TSO (M=2.3846, SD=1.55662) conditions; t(23) = 3.143, p = 0.005. You can see the means of each post-mood state for the two groups in Figure 16.

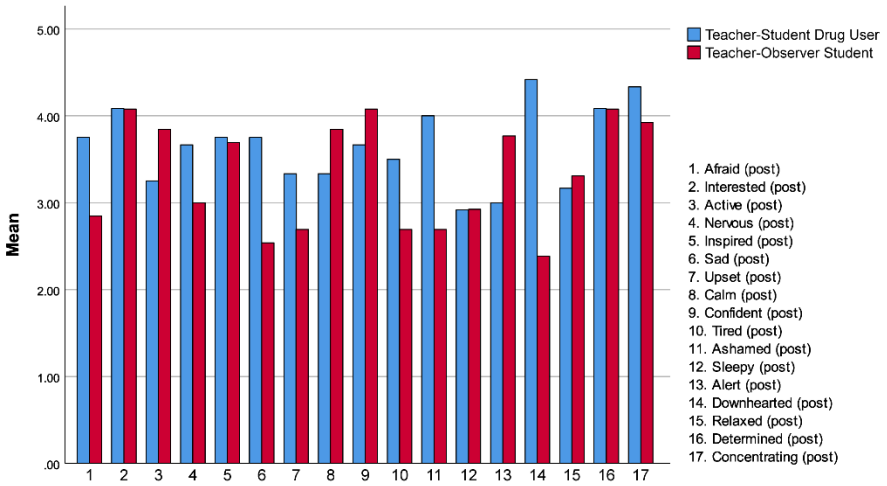


Figure 16: Means of the post- mood states for the two groups

4.7.4.3 Pre-post mood states differences

A paired-samples t-test was conducted to compare the individual mood states scale items and determine differences between them. For the TSDU group, the VR intervention elicited a significant decrease in the levels of fear, before (M=5.5833, SD=1.16450) and after (M=3.7500, SD=2.22077); t(11)=2.421, p = 0.034. Additionally, it elicited a significant decrease in the participants' interest, before (M=4.5833, SD=1.44338) and after (M=4.0833, SD=1.67649); t(11)=2.569, p = 0.026. Moreover, how upset the participants were, was significantly decreased, before (M=5.5833, SD=0.90034) and after (M=3.3333, SD=2.01509); t(11)=3.567, p = 0.004, while it increased their feeling of shame, before (M=1.6667, SD=0.88763) and after (M=4.000, SD=2.21565); t(11)=-2.948, p = 0.013, and decreased the levels of feeling sleepy,

before (M=4.7500, SD=1.28806) and after (M=2.9167, SD=2.06522); t(11)=3.188, p = 0.009.

As far as the TSO group is concerned, the VR intervention decreased the levels of fear, before (M=5.4615, SD=0.96742) and after (M=2.8462, SD=1.86396); t(12)=4.484, p = 0.001. It also decreased the levels of feeling nervous, before (M=4.5385, SD=1.76141) and after (M=3.000, SD=2.000); t(12)=2.497, p = 0.028. It additionally decreased their sadness, before (M=5.2308, SD=1.69085) and after (M=2.5385, SD=1.89804); t(12)=3.530, p = 0.004.
The experience significantly decreased how upset they were, before (M=5.5385, SD=0.96742) and after (M=2.6923, SD=1.93152); t(12)=4.944, p = 0.000. Their level of feeling sleepy was also decreased, before (M=4.3846, SD=1.12090) and after (M=2.9231, SD=1.60528); t(12)=2.413, p = 0.033 and made them feel less downhearted, before (M=5.000, SD=1.29099) and after (M=2.3846, SD=1.55662); t(12)=4.234, p = 0.001.

Before and after their exposure, participants in the TSDU group, had a significant decrease in their levels of fear, interest, how upset they felt and how sleepy, and a significant increase in their levels of shame. Regarding participants in the TSO group, they reported only significant decreases in their levels of fear, nervousness, sadness, how upset they felt, sleepy and downhearted.

Regarding the differences between the two groups, new variables were calculated for each mood state (dmoodstatex = postmoodstatex – premoodstatex), which reflect the degree of change in each mood state. We investigated whether participants' mood states were affected before and after their experience. Between the two groups, the only emotion that was found significant different was “downhearted”, TSDU (M=-0.8333, SD=1.80067) and after (M=-2.6154, SD=2.18092); t(23)=2.217, p = 0.037.

4.7.4.4 Conclusions regarding mood states

Overall, the results indicated that the use of the VR system elicited a statistically significant change in the participant’s negative mood states. The only significant difference between the two groups was found in participants of the TSDU group that

were found significantly more downhearted than those in the TSO group after the VR experience.

4.7.5 Physiological Data

Physiological data were also collected through this study[1]. Brain signals and the heart rate were recorded during the VR experiment. Below there are the results of both the EEG and the heart rate data.

4.7.5.1 EEG

This section presents the analysis of the results concerning EEG. The EEG signals were analyzed using the MATLAB toolbox EEG Lab. The results indicate significant differences between the different perspectives (TSDU and TSO) regarding participants' brainwaves including the alpha and the beta rhythm. Alpha brain activation generation reflects a calm psychological state, while beta activity reflects a more stressful situation (Seo and Lee, 2010). 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).

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.

[1] It is noted that only the collection of this data is part of this thesis. The analysis of the physiological data has been conducted by co-authors of Christofi et al., 2018. For the sake of the reader to have the overall picture of the results of this experiment, the general results in regards to physiological measurements are described here and the rest are given as an Appendix.

You can find detailed results regarding EEG in Appendix A-2.

4.7.5.2 Heart Rate

This section presents the analysis of the results concerning the heart rate measurements. During the VR experience, the HR of the participants was measured. The results indicate a significant difference before and after the VR experience for all the participants. The pre-HR represents the HR before the experiment (M = 80.92 bpm, SD= 10.59 bpm), while post-HR shows the HR after the experiment, (M = 87.21 bpm, SD=10.97 bpm (see Figure 17). Comparing the HR values before and after the exposure to the virtual world using a paired samples t-test indicated that post-HR scores were statistically significantly higher than pre-HR scores, before (M=80.92, SD=10.59) and after (M=87.21, SD=10.97); t(23)=-3.151, p = 0.004.

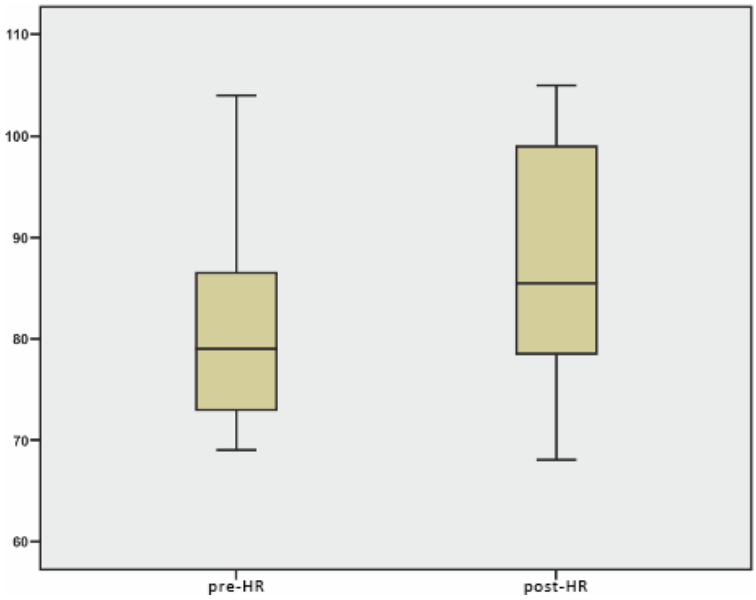


Figure 17: Participant's heart rate before and after the use of VR

Additionally, comparing the HR values with the different perspectives before and after the experiment using a paired samples t-test, indicated that post-HR scores were statistically significantly higher than pre-HR scores for the TSDU before (M=82.00, SD=8.967) and after (M=91.18, SD=9.141); t(10)=-3.590, p = 0.005.

4.7.5.3 Conclusions regarding the physiological data

The results obtained from HR and EEG signal analysis indicate that the participants were in an alert state during the experiment, while beta brainwaves and the increase of their heart rate can be translated into stress and anxiety.

4.8 Conclusions – Study 1

The purpose of this study was to investigate whether different perspectives change the affective attitudes of teachers toward drug users in a school through a virtual school environment. By using VR based methodology to allow teachers to put themselves in the position of a student facing substance use disorder. A significant difference was found in the TSDU group, in the question, whose values were reversed for the analysis "I find it difficult to relate with students going through drug problems.".

Regarding the participants' sense of presence, similar levels of reported presence between the two groups were found, as no significant changes between them were found. Regarding their sense of embodiment, the results show that the participants tended to be more neutral regarding the sense of embodiment, no matter their group, according to their median scores.

Overall, the results indicated that the use of the VR system elicited a statistically significant change in the participant's negative mood states. Beta waves (alertness, critical thinking) were detected in all viewpoints, while alpha waves (relaxation) were detected only in the viewpoints of the students (observer and drug user). A statistical difference between pre- and post-HR between the viewpoints was found in the TSDU, as participants in that group had a significantly higher HR after their experience.

5 Study 2 – Changing affective attitudes toward drug users through a Virtual Reality simulation of their life.

5.1 Introduction and Objective

This chapter focuses on the second study that was conducted for this dissertation.

Study 1 dealt with substance issues inside the school environment. Substance use is also a major societal concern and does not only concern teachers or parents.

Drug users were chosen as the social target in this study as well because they are considered an extreme outgroup that people often struggle to empathize with (Harris and Fiske, 2006). In Study 1, the target group was teachers, and the goal was to change their affective attitudes toward drug users in a school area. In Study 2, we take it a step further, as the target audience is all adults.

Gilbert and Malone (1995) argued that people do not account for the situation sometimes simply because they are not aware of it. Since people do not have all the relevant information, they cannot make a reasonable judgment about someone's behavior. As explained in Section 2.1.2 people tend to overestimate the influence of personality and underestimate the influence of situations, when explaining other people's behavior (Myers, 2010).

The goal of showing the participants the whole journey of this man was to reverse the fundamental attribution error, that people tend to do, which in short says that others do bad things, such as drug use, because they are bad people. In this case and with our narrative, we wanted to show the participants, that in most cases situations drive people to drug use.

The character in the scenario is seen using drugs as a coping mechanism for the death of his mother and the stress from his work. According to the self-medication hypothesis (Khantzian, 1997, 2003), addictive drugs have appeal because during the short term they relieve painful feelings and psychological distress. There is a tendency in society to stigmatize drug users, as people think they use drugs for their enjoyment only. As highlighted by Ethics Unwrapped (2019), the best thing we can do, in order to avoid

doing the fundamental attribution error, is to put ourselves in these people's shoes and try to understand the reasoning behind their actions or mistakes with empathy.

Cocaine was chosen because according to the 2020 European Drug Report, cocaine was the second most commonly used illicit substance in Europe and its use was concentrated among 2.9 million young adults aged 15–34 years, and 4.3 million adults aged 15-64 years (EMCDDA, 2020). Specifically, for Cyprus, according to the Cyprus Country Drug Report 2019 (EMCDDA, 2019), 0.8% of young adults (15-34 years), all male, were reporting use of cocaine. In that year, 811 drug law offenses were reported, and 134 for supply, which shows, that even in a small country like Cyprus, drug use is still a major issue.

Additionally, we followed the suggestion of Bertrand et al.'s (2018) for the embodiment of a digital avatar of an outgroup member that presents traits that contradict stereotypes, which we have done in our study. Following the strategies and suggestions of Bertrand et al.'s (2018), our hypothesis was that participants in the SC condition would be more empathetic after their experience, have more positive attitudes toward drug users, and feel more emotionally close to them, than participants in the NSC condition.

In this study, we developed and compared a VRPT system that supports a number of sensorimotor contingencies (SC condition) and a less immersive perspective-taking system using a desktop computer with minimum support of sensorimotor contingencies (NSC condition), to investigate their effect in changing peoples' affective attitudes toward drug users.

5.2 Materials and Methods

5.2.1 Application

An application was designed and developed in which participants were able to virtually experience some scenes of the life of a person who became a drug user, through his point of view, to debunk stereotypes surrounding drug users. In total, the participants viewed nine scenes from the life of the drug user. The scenario and scenes they virtually experienced are described in more detail in the following sections.

The scenario put the participants in the shoes of a man named Mark, a 28-year-old man, who recently lost his mother due to cancer, and is living with his wife Amanda. It is said in the narrative, that he is stressed due to his workplace, where his boss assigns him many duties. One day at work, Mark's colleague sitting at the desk next to him, invited him to a party, to which he attends. A man there, offers Mark to try out a drug, in this instance; cocaine, for the first time, to "loosen up and have fun," as the drug dealer tells him. Mark, due to dealing with his mother's death and extensive work stress, obeys, follows that man to the bathroom, does drug use for the first time and becomes addicted to cocaine. Then, participants experience the consequences of this action which include his inability to work, which is shown as a scene at work where his boss yells at him for not doing his job right, a visit to his drug dealer and his changing relationship with his wife, who threatens him in the end of the narrative to leave him if he does not seek help for his drug problem. A breakdown of the scenes can be found in Chapter 5.2.2. A video showing the VR application can be found at this link: https://youtu.be/wHrPHlOu8mc.

5.2.1.1 Changes on the avatar

A number of the scenes have a mirror on one of the walls (including the first one for familiarization with the VR equipment and the suit), so that the participants could see the avatar they were embodying and progressively see some of the physical changes, the drug consumed by their avatar.

In this scenario, the drug portrayed is cocaine. The changes that it does to people, which include dilated pupils, increased heart rate, extreme weight loss, bloody nose and cocaine powder running through the nose (The Recovery Village, 2019; Thomas, 2020). These changes were visible to their avatar from the scene after he consumed cocaine in one of the starting scenes (Figure 18) (Scene 5 as described below).

Figure 18: UV textures of the avatar. Normal texture before drug use (left), and with the visible changes, blood running from the nose, and powder (right).

5.2.2 Scenes

Scene 1 – Bathroom: You are in the bathroom, standing in front of the sink (Figure 19). There is a mirror in front of you, where you can look at your avatar for the first time. Amanda, your wife, is standing to your right and informs you that she invited your friends for dinner to take your mind away from work and your mother's loss. This was put in the scenario so that the users have some context and information about their avatar.

Figure 19: Your virtual avatar can be seen through a mirror in Scene 1

Scene 2 – Dinner: You are at the dinner, and your friends are discussing sports at the table (Figure 20). Then one of your friends, Lisa, mentions that you are quiet tonight,

followed by Amanda explaining that it is because of the work stress, among other stuff. In this scene, there is a mirror on the left side of the room, where participants can view their avatar once again.

Figure 20: In Scene 2, there is a mirror on the left of the table

Scene 3 – Work #1: You are in your work office (Figure 21), and your boss is telling you to prepare some files for him before lunch time because important clients are waiting for them. Your boss leaves and your co-worker turns to you and invites you to a party in a few days to release all your stress.

Figure 21: Your avatar's boss, the man in the black suit, is being seen yelling at your avatar

Scene 4 – Party #1: You are at that party, loud music is playing, and people are dancing and drinking around you. Your co-worker, is standing near a table, wearing casual clothes this time, and he is telling you to enjoy yourself. Then, a man with a

white shirt, who stands behind a table with drinks and pills (Figure 22), notices how stressed and serious your avatar is and tells you to follow him.

Figure 22: People at the party, dancing (left). Your coworker in purple shirt and the man in white shirt behind the table, who tells your avatar to follow him (right).

Scene 5 – Party #2: You are in the toilets of the house that the party takes place in. In front of you, there are two sinks with needles, cocaine powder divided into straight lines and razors. The man stands in front of the second sink, sniffs cocaine and then continues to urge your avatar to do the same (Figure 23).

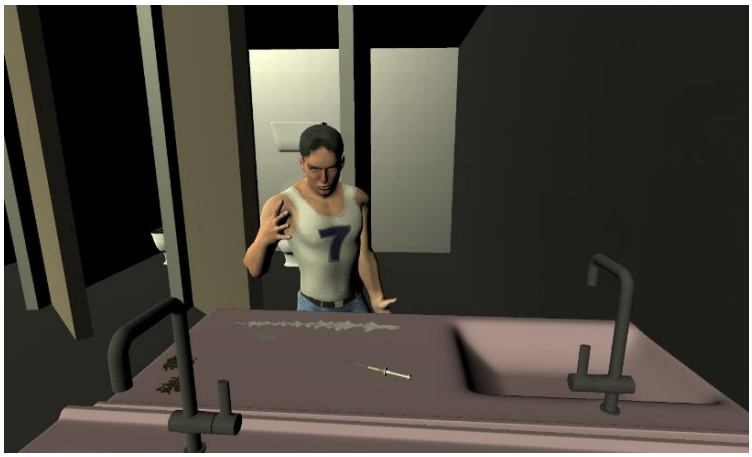


Figure 23: The man is seen doing drug use, and then pressuring your avatar to do the same.

Scene 6 – Drug dealer: You stand in front of your drug dealer who is sitting relaxed at a table where you can see cocaine in lines, razors, a bag and money laying around in packs (Figure 24). The dealer wonders how you can afford all this cocaine, implying that this scene takes place a period after the last one, and that you are a regular drug user by now. The drug dealer warns you that demand for drugs is getting bigger so the prices are getting higher as well and that the next time you should bring more money.

Starting from this scene, participants can view the physical changes cocaine has done to their character, which include weight loss (in the starting scenes Mark appears to have a visible belly so that the change is more noticeable), so in this scene he looks really thin, his eyes are red, he has blood running from his nose, and cocaine power visible on the nose as well. This scene also includes a piece of dramatic music, and the users can also hear their avatar's heartbeat, which beats fast.

Figure 24: The drug dealer, the man who is sitting, and his bodyguard on the right

Scene 7 – Work #2: Your boss yells at you for not showing up to an important meeting the day before (Figure 25) and then your co-worker tells you to look at yourself in a mirror and that he worries about you.

Figure 25: The boss is seen yelling at your avatar once more

Scene 8 – Bathroom #2: You locked yourself in the bathroom of your house (the same one you see in the first scene), and standing in front of the mirror, on the sink you can see cocaine powder and a razor (Figure 26). You can listen to your wife, who is outside the room, wondering why you locked the door and informing you that the food is ready.

Figure 26: The avatars' body is seen slimmer, with blood and powder on the nose area, to indicate the effects of drug use.

Scene 9 – Dining area: You stand in the dining area, your wife is standing by the table and you see your bag opened and cocaine on the table as well as money found by your wife, who is disappointed in you. She says that she noticed a big withdrawal of money from your shared account and this explains all the symptoms you have been showing lately (Figure 27). She wonders what your mother would say about all this and urges you to seek some help or she is going to leave you.

Figure 27: Your avatars' wife is seen yelling at you, after finding out the truth.

The whole script that was written, can be found in Appendix B-1. Additional images from the scenes can be found in Appendix B-2.

5.2.3 Participants

A total number of 40 participants (n = 40) participated in the study, 21 of them male and 19 females. For the recruitment of the participants, we used convenience sampling. A social media post was created for the recruitment of participants.

Ages of participants varied from 18 to 59 with the majority (42.5%) in the range of 18–24 years old. Furthermore, data on participants' experience in using VR environments, indicated that most of the participants (42.5%) had little experience with VR.

5.2.4 Experimental Design

A between-groups design was used to conduct the study. The participants were randomly assigned into two groups, the Sensorimotor Contingencies condition (SC) (n = 20) and No Sensorimotor Contingencies (NSC) condition (n = 20), which are explained further in the following sections. The majority (11) of the participants in the NSC group were aged between (18–24), and for the SC group the majority (8) aged between 25 and 29 years old. Regarding occupation, in the NSC group the majority (12) were students and in the SC group (7) were working in the private sector. The study has been approved by the Research's Ethics and Deontology committee of the Cyprus University of Technology. All participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in the study.

5.2.4.1 SC Condition

This condition supports several sensorimotor contingencies for the user. It required the participants to put on a VR HMD, allowing stereo viewing in 360 degrees of the surrounding environment, supporting head tracking and allowing displacement of the viewing scene in a physical way. Real time tracking of full-body and hands, at the detail of the fingers, movements was also supported and real time mapping of the participant's

movements to the virtual avatar was supported as well (Figure 28). That was achieved by having the participants fitted with a wireless full body motion capture suit and VR data gloves. Wearing both, the participants were virtually embodying the drug user. They were viewing the virtual world in a first-person view and could rotate their head to change their point of view. There was no other stimulation than the first-person perspective view over the body.

Figure 28: The suit allowed for real time, full body motion tracking

The participants could not interact with the application in any way or with the other avatars or virtual items in the virtual world. The participants were required to be standing and could move their body and head around to change their point of view and watch their avatar in the virtual world, which was the drug user, move simultaneously according to their real time movements.

5.2.4.2 NSC Condition

The application of the NSC version was identical with the SC version with the difference being that the participants did not wear any of the equipment mentioned above thus no sensorimotor contingencies were supported. Instead, they were sitting on a chair in front of a desktop computer, viewing the same application, this time, through a flat computer screen and could only turn their point of view with the use of the mouse.

5.2.5 Materials and Technical Setup

The application used for both groups was developed in the Unity software. The models of the avatars in the application were created using the online software Autodesk ®

Character generator, in which a skeleton was also added to the models as well as facial blend shapes, so that their mouths could move according to the dialogues recorded which were recorded using a Philips audio recorder. These recordings were then edited in the Adobe Audition CS6 software.

It is important to note that the majority of the animations seen in the application, like the animations of the person who influences the participants' avatar to use drugs in the party and the bathroom scene, and the avatars' wife, the boss and the colleague at work were recorded by the researcher herself using the Xsens motion capture system, edited in the MVN Animate software, exported as .fbx files and imported into Unity. The rest of the animations were imported from mixamo.com, which offers a variety of characters and animations.

For the SC group, the virtual environment was displayed through an Oculus Rift CV HMD. This has two 1080 × 1200 pixels OLEDs per eye at a 90 Hz display refresh rate, coupled with a positional tracker and built-in headphones. The participants in this group had to wear the Xsens MVN Awinda wireless motion capture trackers for real time body movement tracking that was mapped to their avatar in the virtual world through the Xsens software and the Manus VR – Xsens Edition gloves, which offered finger tracking (see Figure 29).

For the NSC condition, the application was displayed to participants through 1920 × 1080 pixels 24-inch computer screen. A computer mouse was used for the interaction with the application and headphones for the sound (see Figure 30).

Figure 29: One of the participants of the SC condition wearing the Oculus Rift, Xsens Awinda trackers, and Manus VR gloves.

5.2.6 Procedure

Upon arriving at the laboratory, the participants were randomly assigned to one of the two groups, NSC or SC, and were asked to read and sign the consent form. Then, they were given the pre-questionnaire. Representative questions of this questionnaire are shown at the Table 7.

Participants in the SC group were then told to stand in place, as the researcher took a number of body dimension measurements that are required for the Xsens motion capture suit (such as body height, arm span, knee height and others) in order to calibrate the suit correctly, for which the participant had to walk in a straight line and check if all the sensors are put in the right place in the several body parts over the suit. Once this process was completed, participants in the SC group were asked to put on the VR HMD.

For the participants in the NSC group, the procedure was simpler as they were asked to sit in front of the computer screen and wear headphones for the sound.

Both groups were then briefed about the way they could interact with the application. Then, they viewed the application. The intervention lasted approximately 10 min for both groups. Participants completed the same post-intervention questionnaire

immediately after viewing the application. Representative questions of this questionnaire are shown at the Table 7.

Figure 30: One of the participants of the NSC group.

5.2.7 Measures

Two questionnaires were given to the participants in total, which were the same for both groups, NSC and SC.

5.2.7.1 Pre-questionnaire

The pre-questionnaire was given to the participant before their exposure to the virtual world. Using this questionnaire, we gathered demographic data such as age, gender, occupation, hours spent playing video games, experience in using VR environments and computer programming knowledge.

It also included the following two measures:

Individual differences in empathy

Interpersonal reactivity index is a self-report tool that consists of four 7-item subscales answered on a 5-point Likert scale ranging from “Does not describe me well” to “Describes me very well” (Davis, 1983), used to measure individual differences in empathy. The four subscales are: (a) Perspective-Taking scale (PT): the ability to shift perspectives when dealing with other people. (b) Empathic Concern scale (EC): assessment of the degree to which the respondent experiences feelings of warmth, compassion, and concern for the observed individual. (c) Personal Distress scale (PD): measures the individual’s own feelings of fear, apprehension, and discomfort at witnessing the negative experiences of others.

It is important to note, that in the pre-questionnaire, the fantasy scale was not measured, as the participants would experience through an application the life of the drug user, not imagine it. Representative questions of this questionnaire are shown at the Table 8a.

Attitudes toward drug users

This was a 6-item attitudes scale on a 5-point Likert scale (1 = Completely disagree, 5 = Completely agree). It was adapted from the questionnaire used by Batson et al. (1997) and Herrera et al. (2018) to address attitudes toward drug users. Representative questions of this questionnaire are shown at the Table 8b. Two out of the six questions were reverse coded. Higher scores indicate more positive attitudes toward drug users. This questionnaire was given to the participants before and after their exposure, in order to see if their exposure to the application, can change their attitudes toward drug users.

A list of all the pre-questionnaire measures can be found below (Figure 31).

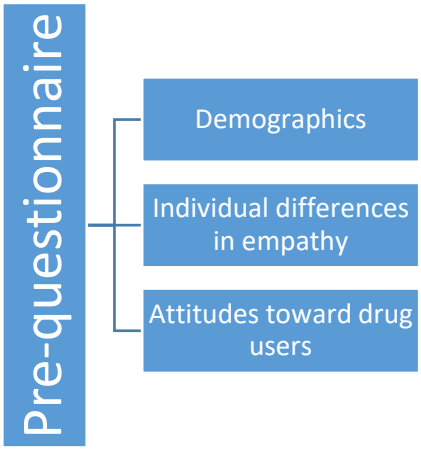


Figure 31: Pre-questionnaire measures

5.2.7.2 Post-questionnaire

The questionnaire was given to all participants, regardless of their group, after their exposure included questionnaires measuring their level of empathy and personal distress, the Inclusion of the Other in the Self scale, and the same questions regarding their attitudes toward drug users as the pre-questionnaire. It also included questions regarding presence [Place Illusion (PI) and Plausibility of the situation (Psi)], Body

Ownership and Agency (BOA). Representative questions of this questionnaire are shown at the Table 6.

Empathy

Participants were asked to rate the extent to which they felt soft hearted, touched, sympathetic, or compassionate throughout the intervention by using a 7-point Likert scale (1 = Not at All, 7 = Very much). The results of these four questions were used to create an index of empathic concern. This measure was adapted from Batson et al. (1997). Representative questions of this questionnaire are shown at the Table 8c.

Personal distress

Participants were asked to rate the extent to which they felt uneasy, troubled, distressed, or disturbed throughout the intervention by using a 7-point Likert scale (1 = Not at All, 7 = Very much). The results of these four questions were used to create an index of personal distress. This measure was also adapted from Batson et al. (1997). Representative questions of this questionnaire are shown at the Table 8d.

Closeness to the drug user

The Inclusion of Other in the Self (IOS) scale measured how close the participants felt to the drug user. Developed by Aron et al. (1992), this scale depicts seven drawings of increasingly overlapping circles, anchored by the first picture of two non-overlapping circles and the seventh picture of two almost completely overlapping circles. Participants had to choose the picture that best represented the extent to which he/she felt connected to the drug user. The pictures are coded from 1 to 7 with the larger numbers indicating a closer relationship with the drug user.

Place illusion (PI) and plausibility of the situation and the virtual people

Place illusion (PI) refers to the sense of "being there" in a virtual world (Slater, 2009). PI was measured using a 5-item questionnaire on a 5-point Likert scale (1 = Not at all, 5 = Very much). Representative questions of this questionnaire are shown at the Table 8e.

The Plausibility of the situation (Psi) is the illusion that "what is apparently happening is really happening (even though you know that it is not)". In the questionnaires, Psi was divided into two aspects; the Psi, and plausibility of the virtual people (PVP), which is if the participants felt that the virtual people were behaving, moving, reacting as if they were real. They were measured using 6-item and 5-item questionnaires respectively, on a 5-point Likert scale (1 = Not at all, 5 = Very much). Representative questions of this questionnaires are shown at the Table 8g and Table 8h for Psi and PVP respectively.

Body ownership and agency

According to Tsakiris et al. (2006) body ownership refers to the sense that one's own body is the source of sensations. Gallagher (2000) defined the sense of agency as "the sense that I am the one who is causing or generating an action." They were measured using a 4-item questionnaire on a 5-point Likert scale (1 = Completely agree, 5 = Completely disagree). Representative questions of this questionnaire are shown at the Table 8f.

A list of all the pre-questionnaire measures can be found below (Figure 32).

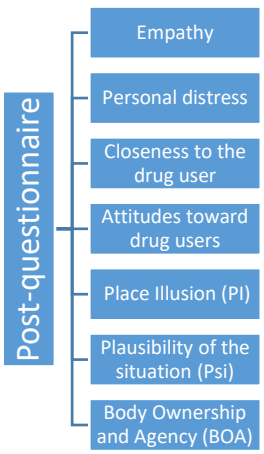


Figure 32: Post-questionnaire measures

Table 8: Sample of questions in pre and post questionnaires

Sample of measures
Pre Measurements (Sample questions)
a) Individual differences in empathy
The following statements inquire about your thoughts and feelings in a variety of situations. For each item, indicate how well it describes you by choosing the appropriate letter on the scale at the top of each question
1. I often have tender, concerned feelings for people less fortunate than me
2. When I see someone being taken advantage of, I feel kind of protective towards them
3. When I see someone being treated unfairly, I sometimes don't feel very much pity for them
4. When I'm upset at someone, I usually try to "put myself in his or her shoes" for a while
b) Attitudes toward drug users
Using the scale below, please indicate your agreement with each of the following statements.
1. For most drug users people, it is their own fault that they are drug users.
2. Our society does not do enough to help drug users.
3. Most drug users could have avoided becoming that.
4. Our society should do more to protect the welfare of drug users.
Post Measurements (Sample questions)
c) Empathy
1. Softhearted
2. Sympathetic

d) Personal Distress
1. Distressed
2. Uneasy
e) Place Illusion (PI)
Now you'll read some statements regarding the experience you had. Please indicate whether each statement applies to your experience.
1. I had a sense of "being there" in the virtual environments…
2. When you think back about your experience, do you think of the virtual environments more as images that you saw, or more as somewhere that you visited?
3. I think of the school space as a place in a way similar to other places that I've been today…
f) *Body Ownership and Agency (BOA)*
1. During the experience I felt as though I had two bodies
2. During the experience I felt that the virtual body belonged to someone else
3. During the experience I felt that the body I saw when looking down toward myself was my own body (even though it didn't look like me)
g) ***Plausibility of the Situation (Psi)***
1. How much did you behave within the scenes as if the situations were real?
2. How much were the thoughts you had within the experience the same as if it had been a real situation?
3. Overall how much did you treat the experience as if it were real?
h) ***Plausibility of the Situation (Psi)***
1. How much did you behave as if the virtual people were real?
2. How much were your thoughts in relation to the virtual people as if they were real?

5.3 Results of Study 2

All results were obtained using the SPSS Software v.24 by IBM.

The means, standard deviations and the significant differences of the mean between the groups for the outcome variables; IRI, Inclusion of the Other in the Self (IOS), Empathy, Personal Distress, Pre-, and Post-Attitudes toward drug users by condition (NSC and SC) are summarized in Table 9.

Table 9: Means, standard deviations and p-values for all outcome variables for both groups.

Measures	**Condition**				
	NSC		**SC**		**p-values**
	Mean	**SD**	**Mean**	**SD**	
IRI	3.38	0.52	3.68	0.52	p = 0.079
IOS	2.85	1.89	3.75	1.55	p = 0.109
Empathy	4.850	1.71	4.90	1.42	p = 0.921
Personal distress	4.45	1.64	4.88	1.54	p = 0.392
Pre-Attitudes	3.383	0.63	3.60	0.56	p = 0.261
Post-Attitudes	3.57	0.63	3.78	0.58	p = 0.287

SD=Standard deviation

5.3.1 IRI

An independent-samples t-test was conducted to compare the level of empathy of the participants before their exposure in the two groups. Although the mean for the SC group is higher than the NSC group, there was not a statistically significant difference in the IRI scores for the NSC group (M = 3.3857, SD = 0.52504) and SC group (M = 3.6857, SD = 0.52787) conditions; t(38) = -1.802, p = 0.079.

Separately for each subscale, higher scores were shown in all three subscales of IRI for the SC group, but there was also no significant difference in the participants' trail-levels of empathy in any of the three subscales [empathetic concern (EC), perspective-taking

(PT), and personal distress (PD)], of the IRI scales between the two conditions. More specifically, regarding the EC scale, for the NSC group (M = 3.1357, SD = 0.65297) and SC group (M = 3.4786, SD = 0.58860) conditions; t(38) = -1.744, p = 0.089. Next for the PT scale, for the NSC group (M = 3.7000, SD = 0.65695) and SC group (M = 3.8857, SD = 0.56500) conditions; t(38) = -0.959, p = 0.344. Finally for the PD scale, for the NSC group (M = 2.7143, SD = 0.58075) and SC group (M = 3.1071, SD = 0.80928) conditions; t(38) = -1.764, p = 0.086.

This suggests that the two conditions were balanced in terms of pre-intervention empathy and they were successfully randomly assigned into these two groups.

Gender differences were found in the SC group regarding IRI. More specifically, there was a significant difference between males (M = 3.2857, SD = 0.54482) and females (M = 3.8120, SD = 0.38961); t(38) = -3.480, p = 0.001. This suggests that females in the SC group had significantly higher levels of empathy than the males in the SC group before their exposure. More separately in the sub-scales, females only in the SC group had significantly higher levels of EC (M = 3.6090, SD = 0.48525) over the males (M = 3.0340, SD = 0.64508); t(38) = -3.159, p = 0.003 as well as levels of PD (M =3.2406, SD = 0.64604) over the males (M = 2.6122, SD = 0.66875); t(38) = -3.016, p = 0.005. Females also had higher but not significantly different levels of PT (M = 3.9624, SD = 0.50134) over the males (M = 3.6395, SD = 0.67252); t(38) = -1.707, p = 0.096. This aligns with the findings of Davis (1980), where women displayed higher scores than men for each of the four subscales or IRI.

A Pearson product-moment correlation coefficient was computed to estimate the relationship between the IRI total score of the participants that was measured before their exposure and their attitudes toward drug users before and after their exposure. Results indicate significant positive correlations between these variables. More specifically, participants that reported more empathetic before their exposure also had more positive attitudes toward drug users after their exposure (positive medium correlation; r = 0.353, n = 40, p = 0.025) and before their exposure (positive strong correlation; r = 0.412, n = 40, p = 0.008). Separately in each of the two groups, this correlation was observed to a significant level only in the NSC group for their post-attitudes scores (r = 0.452, n = 20, p = 0.045) where a significant medium positive correlation was found.

5.3.2 Attitudes Toward Drug Users

Both groups showed a significant difference in their reported attitudes toward drug users before and after their exposure. Regarding the pre-attitudes, the median score for the SC group was 3.33 out of 5, and 3.50 out of 5 for the NSC group. Regarding the post-attitudes, the median score for the SC group was 3.50 out of 5, and 3.83 out of 5 for the NSC group.

There was a significant difference in the attitudes of the participants in the NSC group for their attitudes before their exposure (M = 3.3833, SD = 0.63084) and after (M = 3.5750, SD = 0.63861); t(19) = -2.529, p = 0.020. Similarly, there was a significant difference in the attitudes of the participants in the SC group for their attitudes before their exposure (M = 3.600, SD = 0.56816) and after (M = 3.7833, SD = 0.58013); t(19) = -2.125, p = 0.047.

There was not a significant difference between the two groups in their pre-attitudes, NSC (M = 3.3833, SD = 0.63084) and SC (M = 3.600, SD = 0.56816) conditions; t(38) = -1.141, p = 0.261. This means the groups were balanced in their pre-attitudes toward drug users before their exposure.

Gender differences were found in the NSC group regarding both pre-attitudes and post-attitudes. More specifically, there was a significant difference regarding the pre-attitudes of males (M = 3.2143, SD = 0.52742) and females (M = 3.7982, SD = 0.53742); t(18) = -3.466, p = 0.001. Also, there was a significant difference regarding the post-attitudes too, of males (M = 3.4444, SD = 0.57815) and females (M = 3.9386, SD = 0.55056); t(18) = -2.761, p = 0.009. Both these results suggest that females in the NSC group had more positive attitudes toward drug users both before and after their exposure than the males in the NSC group.

There was not a significant difference between the two groups in their post-attitudes, NSC (M = 3.57, SD = 0.63) and SC (M = 3.78, SD = 0.58) conditions; t(38) = -1.08, p = 0.287.

5.3.3 IOS

Regarding their closeness to the drug user, the median score for the SC group was 2.0 out of 7, and 4.00 out of 7 for the NSC group. There was not a significant difference in

the closeness of the participants toward the drug user between the two groups, NSC (M = 2.85, SD = 1.899) and SC (M = 3.75, SD = 1.552) conditions; t(38) = 0.084, p = 0.109. Regarding the SC group, IOS was positively significantly correlated to their reported levels of post attitudes (r = 0.512, n = 20, p = 0.021) and their reported levels of empathy (Figure 33) (r = 0.686, n = 20, p = 0.001). This means that participants in the SC group who reported being emotionally closer to the drug user, also reported more positive attitudes toward drug users after their exposure and being more empathetic.

Regarding the NSC group, IOS was positively significantly correlated only to their reported levels of BoA (r = 0.508, n = 20, p = 0.022). This means that participants in the NSC group who reported being emotionally closer to the drug user, also reported higher levels of BOA.

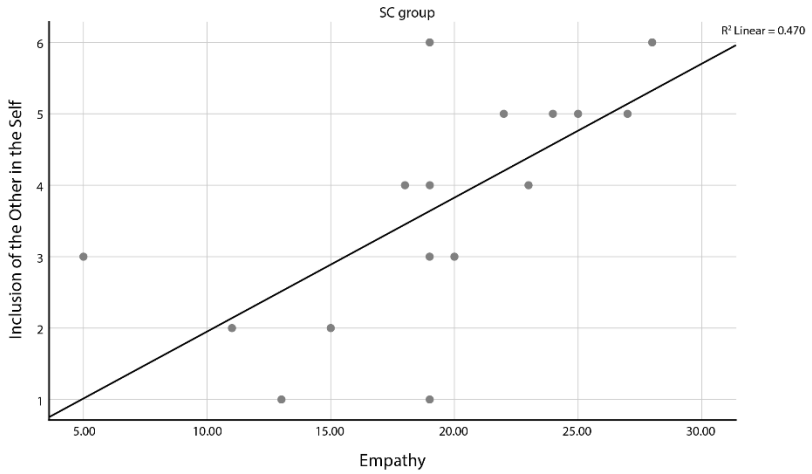


Figure 33: Strong correlation between closeness to the drug user and empathy in the SC group.

5.3.4 Empathy

The participants' empathy was measured after their exposure. The overall reliability of the index was good, Cronbach's alpha = 0.921. The median score for the SC group was 4.8750 out of 7, and 4.8750 out of 7 for the NSC group. There was not a significant difference in the empathy levels between the two groups, NSC (M = 4.8500, SD = 1.71947) and SC (M = 4.9000, SD = 1.42210) conditions; t (38) = -0.100, p = 0.921.

Regarding the NSC group; empathy was positively significantly correlated to their reported levels of BoA (r = 0.475, n = 20, p = 0.034), their reported levels of PVP (r =

0.564, n = 20, p = 0.010) and finally their personal distress levels (r = 0.630, n = 20, p = 0.003). This means that the more empathetic they reported they felt after their exposure, the more distressed they were and reported higher levels of body ownership, agency and plausibility of the virtual people.

5.3.5 Personal Distress

The participants' personal distress was measured after their exposure. The overall reliability of the index was good, Cronbach's alpha = 0.889. The median score for the SC group was 4.75 out of 7, and 5.3750 out of 7 for the NSC group. There was not a significant difference in the personal distress levels between the two groups, NSC (M = 4.8875, SD = 1.64357) and SC (M = 4.8875, SD = 1.54850) conditions; t(38) = -0.866, p = 0.392.

Regarding the NSC group, personal distress was positively significantly correlated to their reported levels of PI (r = 0.457, n = 20, p = 0.043), their reported levels of PSI (r = 0.514, n = 20, p = 0.020) and their levels of PVP (r = 0.513, n = 20, p = 0.021). This means that the more distressed they felt, the higher the levels of PI, Psi, and the virtual people were.

5.3.6 Factor Analysis

For the questionnaire data regarding the participants' experience, factor analysis was carried out to reduce the number of questionnaire variables, which also has the advantage of transforming ordinal variables into continuous ones.

Corresponding factor scores were used, and the interpretation of each factor was identified. Subsequent analysis on the derived variables was done using independent samples t-test.

Figure 34 shows the bar chart of the means and standard errors of the derived factor scores for all four variables Place Illusion (PI), Body Ownership and Agency (BOA), Plausibility of the situation (Psi), and Plausibility of the virtual people (PVP).

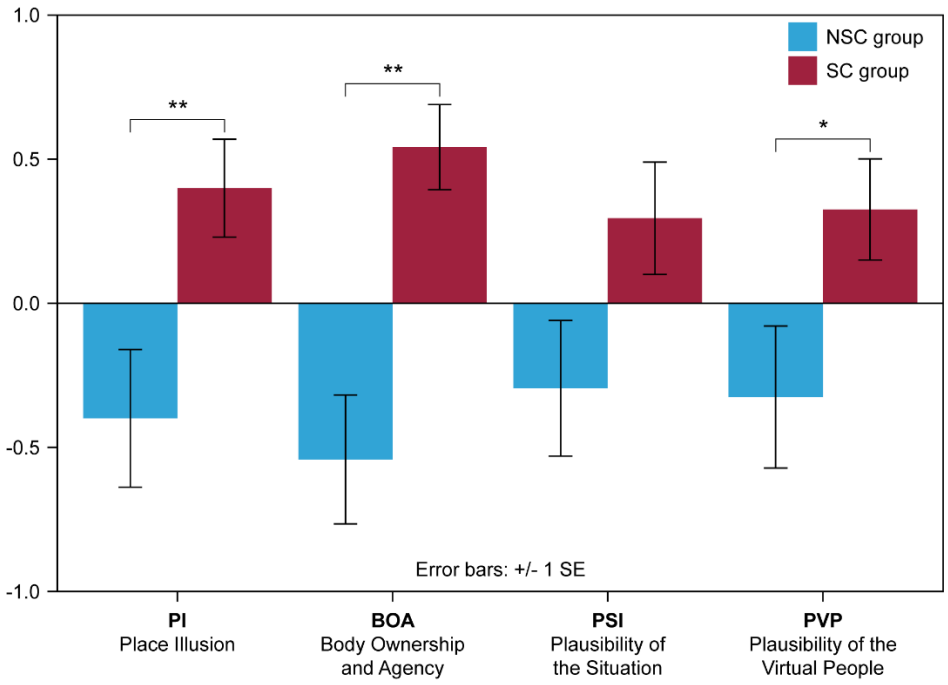


Figure 34: Means and standard errors of the derived factor scores for all four variables PI, BOA, PSI, and PVP.

5.3.6.1 Place Illusion (PI)

Factor analysis in the questionnaire on the participants reported PI has resulted in a single factor. The factor loadings of the scoring variable PI are shown in Table 10. The factor is interpreted as "the illusion of being there." There was a statistically significant difference between the two groups. Participants in the SC condition reported higher levels of presence (M= 0.399, SE=0.169) compared to participants in the NSC condition (M=-0.399, SE=0.238). An independent samples t-test showed that the above differences are significant [t(38) = -2.728, p = 0.010].

Table 10: Factor analysis for Place Illusion, resulting in a single factor F1 and the corresponding scoring coefficients of the factor score yp1.

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**yp1**

there	0.886	0.257
real	0.808	0.234
visited	0.787	0.228
lab	0.815	0.236
overwhelm	0.854	0.247

5.3.6.2 Body Ownership and Agency (BOA)

Factor analysis in the questionnaire on the participants reported BOA has resulted in a single factor. The factor loadings of the scoring variable BOA are shown in Table 11. The factor is interpreted as "the sense that one's own body is the source of sensations and the sense that I am the one who is causing or generating an action." There was a statistically significant difference between the two groups. Participants in the SC condition reported higher levels of BOA (M=0.541, SE=0.147) compared to participants in the NSC condition (M=-0.541, SE=0.223). An independent samples t-test showed that the above differences are significant [t(38) = -4.047, p = 0.000].

Table 11: Factor analysis for Body Ownership and Agency, resulting in a single factor F1 and the corresponding scoring coefficients of the factor score yboa1.

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**yboa1**
mybody	0.924	0.393
twobodies	0.426	0.181
agency	0.892	0.379
otherbody	-0.721	-0.307

5.3.6.3 Plausibility of the Situation (Psi)

Factor analysis in the questionnaire on the participants reported Psi has resulted in a single factor. The factor loadings of the scoring variable PSI are shown in Table 12. The factor is interpreted as "the illusion that events are actually happening." Participants in the SC condition rated their sensed illusion more positively (M=0.294, SE=0.194) compared to participants in the NSC condition (M=-0.294, SE=0.235). An independent samples t-test showed that the above differences are not significant [t(38) = -1.930, p = 0.061].

Table 12: Factor analysis for Plausibility of the situation, resulting in a single factor F1 and the corresponding scoring coefficients of the factor score ypsi1.

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**ypsi1**
behavereal	0.911	0.196
emotionreal	0.881	0.213
thoughtsreal	0.823	0.199
behaveasifreal	0.821	0.199
physicalreal	0.807	0.196
experiencereal	0.833	0.202

5.3.6.4 Plausibility of the Virtual People (PVP)

Factor analysis in the questionnaire on the participants reported PVP has resulted in a single factor. The factor loadings of the scoring variable PVP are shown in Table 13. The factor is interpreted as the "behavioral, physiological, emotional, and thinking responses as if the people were real." There was a statistically significant difference between the two groups. Participants in the SC condition reported higher levels of PVP (M=0.325, SE= 0.175) compared to participants in the NSC condition (M=-0.325, SE=0.246). An independent samples t-test showed that the above differences are significant [t(38) = -2.153, p = 0.038].

Table 13: Factor analysis for Plausibility of the virtual people, resulting in a single factor F1 and the corresponding scoring coefficients of the factor score ypvp1.

Variable	Factor Loadings	Scoring Coefficients
	F1	**ypvp1**
peoplereal	0.876	0.243
emotionpeople	0.928	0.257
thoughtspeople	0.863	0.239
physicalpeople	0.721	0.200
behaveaspeople	0.847	0.234

5.4 Conclusions – Study 2

The aim of this study was to investigate the role of supported sensorimotor contingencies when attempting to change peoples' affective attitudes toward drug users, by comparing a VR system that offered perception through sensorimotor contingencies (SC condition) and a system that did not offer that (NSC condition), by showing the participants scenes from the life of a drug user.

Although the SC group had higher means in all the measures, as seen in Table 8, they were not significantly different from those of the NSC group. This aligns with the results of Herrera et al. (2018) that showed that the differences between mediated perspective-taking tasks, regardless of how immersive they are, were not significant in terms of IOS, empathy or personal distress.

The lack of true interactivity could have impacted the results. Participants of both groups were simply viewers of the scenario presented through them, not being able to interact with objects or the virtual people. Participants in the SC group, although their bodies were real-time tracked and their body movements were mapped to the avatar, were not able to grab objects or interact with the virtual environment in any way. Participants in the NSC group, could only change their point of view with the mouse. Involving the participants in the scenario, could have resulted in a higher sense of

empathy, or even giving the participants choices throughout the scenario, so that they experience a different experience depending on their choices. Participants could also interact with objects in the virtual world, like the syringes or the money, and have a choice whether they want to do drug use, or buy more drugs from the dealer.
Both groups showed a significant difference in their reported attitudes toward drug users before and after their exposure which means that both interventions succeeded in eliciting more positive attitudes toward drug users to the participants. Participants in the VR group reported significantly higher levels of PI, BOA, and PVP but not the situation. The results could be explained by the fact that most of the participants (60%) had no or little experience with VR and maybe this new experience and technology distracted them from experiencing fully the scenario, resulting in similar levels of empathy and personal distress. This is in line with research showing that immersive VR technologies can have an overwhelming impact on participants (Van der Heijden, 2004; Freina and Canessa, 2015).

The SC groups' higher levels of empathy and body ownership could explain the correlation between their closeness to the drug user and empathy as well as their positive attitudes toward drug users. This is in line with the study by Maister et al. (2013) that showed the more intense the participants' illusion of ownership over a dark-skinned rubber hand, the more positive their implicit racial attitudes. Similarly, Gonzalez-Liencres et al.'s (2020) study found that the participants' level of identification with the female avatar correlated with the decrease in prejudice against women.

Furthermore, this study aimed to show the participants, that in most cases, people end up doing drug use because of bad situations that they are going through in life, and they find "relief " and an "escape" in drug use. Considering that, the scenes and scenario created, wanted to reflect the journey of a person, before drug use and after, and the consequences it has in their health, life, family and workspace.

Future studies should focus more on the negative aspects that drug use has on drug users and their life. Future studies should also investigate the role of agency and interactivity in empathy and attitudes toward stigmatized people.

Interactivity has been found to increase empathy (Vorderer, Knobloch & Schramm, 2001), and it can be utilized in VR applications. As many companies are releasing VR

headsets every year with way more features and less required equipment to allow hands and even body tracking, it would be interesting to compare in future studies, the difference between low vs. high-cost VR and tracking equipment in supporting sensorimotor contingencies. Examples of that could include the comparison of motion tracking technologies like the more affordable Microsoft Kinect and a more expensive specialized motion tracking suit like the one used by the participants of the SC group in the current study, or even different cost HMD's which offer less or more tracking possibilities.

The findings of this study provide more evidence that shows that VRPT, can be used to induce empathy of the participants toward members of stigmatized groups. Further research is needed to investigate how perception through sensorimotor contingencies can be exploited to the fullest and be used as an effective method to change peoples' affective attitudes toward stigmatized by society people.

6 Study 3 – Changing peoples' cognitive attitudes about an archaeological site

6.1 Introduction and Objective

This chapter focuses on the third and final study that was conducted for this dissertation.

Research and efforts on attitude change are not only focused on trying to change people's affective attitudes or behaviour toward other people and groups of people that are stigmatized by society. Attitudes, as mentioned in previous chapters and is defined in this dissertation, include our cognitive attitudes about an entity as well.

With ubiquitous computing evolving and devices, such as VR headsets allowing more immersive experiences compared to traditional desktop computing, Virtual Heritage is gaining increasing interest. Digital technology can make such sites virtually accessible and provide educational information at the same time. An extensive overview of the literature addressing social computing in the context of cultural heritage, with a particular focus on issues of accessibility, social inclusion, and privacy can be found in the study by Kosmas et. al (2020).

Toward this goal, a digital reconstruction of the archaeological site of Choirokoitia was created. Choirokoitia is one of the most important prehistoric sites in the eastern Mediterranean. Choirokoitia (2021) is a Neolithic settlement located in the district of Larnaca, Cyprus. The excavated site of Choirokoitia is intact and includes all the attributes that express an outstanding universal value. Choirokoitia is included in World Heritage list of Unesco and given enhanced protection status.

A preliminary study (Christofi et al., 2018), conducted specifically for Choirokoitia, assessed the learning performance of the users and their interest in the topic. Findings demonstrated a strong significant improvement in learning performance, as 15 out of the 19 people who participated demonstrated an improvement in learning performance. Additionally, the interest of six participants was increased. This preliminary was limited since it lacked a comparison between different technologies, it had a small number of participants, and the motion sickness, which was experienced by a few participants, made those results less robust.

In this study, given that a 3D digital reconstruction can be used along with different technologies, an interactive application was designed and developed, where users can navigate and get information about the site, for two different systems: Virtual Reality (VR) systems and desktop computers. A study was conducted to examine whether the use of a VR-based simulation can change peoples' cognitive attitudes about an archaeological site more effective than a more traditional method.

6.2 Materials and Methods

6.2.1 Materials

An initial version of a VR application was developed by Zoe Anastasiadou, Maria Michaelidou, Ioanna Papamichael, and Katerina Pieri, students of the course MGA444: Virtual Reality of the Department of Multimedia and Graphic Arts of the Cyprus University of Technology. A three-dimensional (3D) digital reconstruction of the archaeological site of Choirokoitia (Figures 35, 40), which was created based on real photographs taken on the site and highly accurate modeling of the geometry. We also recorded a set of audio clips with historical information about Choirokoitia. Using the 3D reconstruction and the recorded audio, we developed a new version of an existing Interactive VR Application described in Christofi et al. (2018). Additionally, we developed an Interactive Desktop Application in such a way to provide the same information with a VR Application in order to compare the medium. The two applications, the VR Application and the Desktop Application, that have been developed and evaluated through the feasibility study are described below.

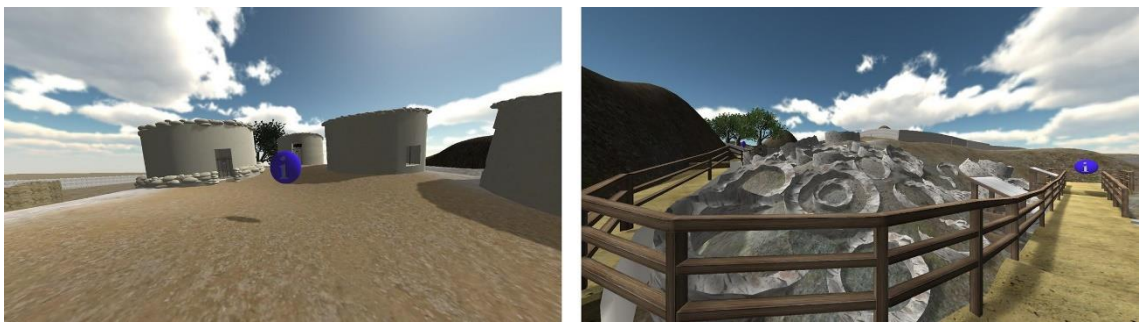


Figure 35: Views from the 3D reconstruction of the archaeological site of Choirokoitia where information points are shown. The virtual reconstruction visualizes the archaeological site as it

stands today, including the real reconstructed houses located near the settlement (left) and the ancient ruins (right) of the settlement.

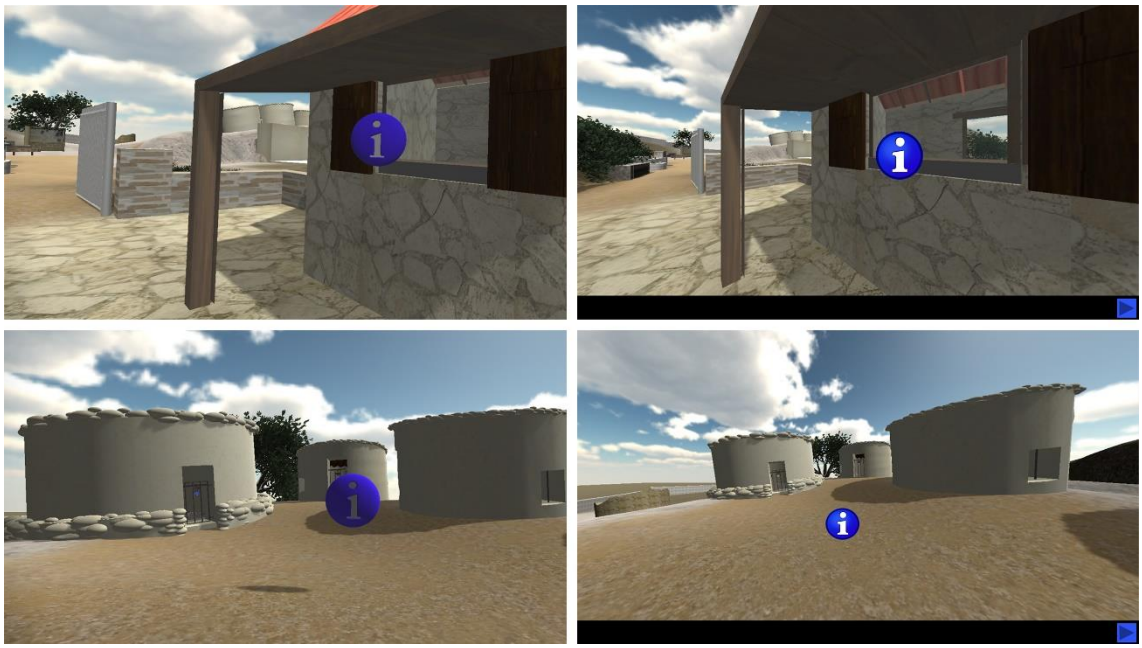


Figure 36: Views from the 3D reconstruction of the archaeological site of Choirokoitia, as shown in the VR Application (top left and bottom left) and the Desktop Application (top right and bottom right).

6.2.2 VR Application

The VR Application used in this study is an improved version of the previously developed VR Choirokoitia application (Christofi et al., 2018). The new version integrates a recent technique developed to minimize the dizziness that was occurring to a great extent to the participants, as is stated in the relevant publication (Fernandes and Feiner, 2016). This technique requires a dynamic reduction of the field of view (FoV) depending on the user's movement and rotation in the virtual environment. Specifically, the FoV was gradually decreased, using a vignetting effect (Figure 37) as the user's navigation (movement and rotation) speed increased, and it increased as the user's navigation speed decreased. The change in the FoV was slow and gradual, so as not to distract the user. Note that the dynamic reduction of the FoV only takes into account the navigation using the video game controller, which causes the dizziness, and not the movement and rotation applied using the HMD's head tracking.

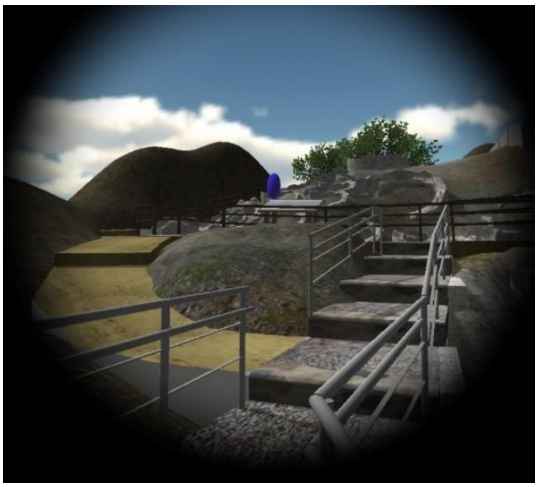


Figure 37: Example of dynamic reduction of the field of view in the VR Application

To further improve the previous version of the VR Application, we also minimized the intervention with the participants during the time that they were immersed in the VR Application. In this new version, we gave them all the instructions through the application and achieved their familiarization with the application's functionality by having a training session at the very beginning of the experience. The training phase took place in a virtual space outside the virtual archaeological site, in a neutral scene, to avoid receiving information about Choirokoitia before the main application began.

In the main VR Application, participants were free to navigate through the 3D reconstruction of Choirokoitia using a video game controller. The application required that the participants put on a VR HMD (Figure 38), which offered a first-person stereoscopic view of the environment and the ability to physically change the looking direction with head rotations.

Figure 38: A participant using the VR Application.

While navigating, participants listened, through the HMD headsets' headphones, to eight audio recordings, in total, containing information related to the archaeological site. The audio clips lasted ~30 s each. The recordings were triggered by collision with 8 information points, visualized by floating 3D icons (Figures 36, top left; Figure 36, bottom left) that were located at various parts of the virtual archaeological site. The information presented in each of those recordings was related to the specific area the participant was exploring at that time. A video showing the VR application can be found at this link: https://youtu.be/ObdgnQnN7YA.

6.2.3 Desktop Application

To test the impact of VR, we designed a non-immersive Desktop Application as a control condition. It provides the user with the same visual and audio information but without the immersive features of the VR technology (3D stereo projection, free navigation, free head movements based on head tracking). The Desktop Application was designed in such a way that it would be easy for a person with basic computer skills to develop, in contrast to the VR Application, which requires advanced skills to develop, such as programming skills. The Desktop Application was developed using 2D rendered images based on the same 3D reconstruction of the site as was used in the VR Application instead of real photographs of the archaeological site, so as to not provide different visual content. The 2D rendered images were created regarding specific points of view selected in such a way to have the rendering of areas that included all eight

points of interest, where information points existed, as well as areas along the route between any two consecutive information points (Figure 39). Like the VR Application, in order to minimize the intervention with the user while conducting the study, we provided all the instructions through digital material at the beginning of the Desktop Application.

Figure 39: A participant using the Desktop Application.

Interactivity was achieved with the mouse button (Figure 40, top right; Figure 40, bottom right). The participants were able to move to the next rendering of a virtual area by clicking on a button that was placed on the bottom right corner of the screen. Information points were triggered by clicking on corresponding small icons like those in the VR group. The participants in the Desktop group received identical audio recorded information as those in the VR group while they were looking at the rendering from the corresponding viewpoint.

6.2.4 Technical Setup

The 3D reconstruction of Choirokoitia was created in Autodesk Maya 2015 and was textured using as reference the original photographs taken from a visit to the archaeological site. The reconstruction was done with high precision and accuracy based on photos and maps and included not only the archaeological buildings but also the surrounding area as it stands today (Figure 40). The stereo audio recordings were

edited in Adobe Audition CS6. The VR Application was developed with Unity 2017.1.2 software, and the virtual environment was displayed through an Oculus Rift CV HMD.

Figure 40: The archaeological site of Choirokoitia has been virtually reconstructed with attention to the structural details of the site (top) and accuracy on spatial locations of the houses (bottom).

This has two 1,080 × 1,200-pixel OLEDs per eye at a 90- Hz display refresh rate, coupled with a positional tracker and built-in headphones. A video game controller was used for navigation inside the virtual space. The interactive Desktop Application was created using Microsoft PowerPoint. We used screenshots of renders of 3D reconstructions within the Unity software to achieve a visual resemblance to the VR Application. The application was displayed to participants through a 1,920 × 1,080 pixel 15.6-inch computer screen. A computer mouse was used for interaction with the application.

6.2.5 Experimental Design

The study had a between-groups design. Participants were randomly assigned to one of two experimental groups: the VR group or the Desktop group. The VR Application was

used by the participants assigned to the VR group, and the Interactive Desktop Application was used by the participants in the Desktop group.

6.2.5.1 Ethics Statement

All participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in this study.

6.2.6 Participants

Forty adults (N = 40), male and female participants, aged 20– 54 years (mean ± SD age 26.65 ± 7.53), participated in the study. After signing an informed consent form, participants were randomly allocated to either the VR or the Desktop group. Participants had no or little prior experience with VR technology. Table 14 presents relevant descriptive data for each condition, the total number of participants, mean ages, median and IQR values for experience in VR (1 = 0, 2 =“<1,” 3 =“1–2, . . . 5 =“>5”), and frequency of previous visits to archaeological sites. Codes refer to a 1–5 Likert scale, where 1 indicates least agreement and 5 most agreement with the statement.

Table 14: Experimental design and distribution of participants by condition.

	Condition	
	VR	**Desktop**
N (Males/Females)	20 (7/13)	20 (10/10)
Mean ± S.D Age	24.75±5.48	28.55±8.9
Median Code VR Experience (IQR)	2 (1)	2 (1)
Median Code Archaeological Site Visits (IQR)	3 (1)	3 (1)

6.2.7 Measurements

Participants were assessed on their sense of presence, level of user experience, attitudes toward the archaeology of Cyprus, and learning performance through questionnaires.

6.2.7.1 Presence

The sense of presence was measured with a three-item questionnaire (Table 15a) based on the presence questionnaire developed by Slater et al. (1994). Presence can be characterized as "the illusion of 'being there' in the environment depicted by the VR displays" (Slater and Sanchez-Vives, 2016). Presence was rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This questionnaire was given to participants right after their experience.

6.2.7.2 User Experience

To assess the user experience, we designed a four-item questionnaire (Table 15b) evaluating the overall experience, the image and audio quality, and whether participants would be willing to try a similar experience in the future. Participants rated their experience on a Likert scale ranging from 1 (negative) to 5 (positive). This questionnaire was also given to the participants right after their experience.

6.2.7.3 Attitudes

A four-item questionnaire (Table 15c) on a Likert scale ranging from 1 (negative) to 5 (positive) was designed to measure participants' attitudes toward the archaeology of Cyprus. This is interpreted as the intention to acquire further knowledge about Choirokoitia or to visit this or a different archaeological site in the future. This questionnaire was given to the participants before their exposure (preAttitudes) and again right after their exposure (postAttitudes). The variable of interest was the Change in Attitude (dAttitudes = postAttitudes – preAttitudes), where positive values indicate an increase in participants' intention to learn more about the archaeology of Cyprus or visit archaeological sites and negative values a decrease.

6.2.7.4 Learning Performance

Participants' learning about the archaeological site was assessed with a 10-statement multiple-choice questionnaire that evaluated participants' knowledge of the archaeological settlement of Choirokoitia (e.g., "What was the shape of the houses in the archaeological site?," "What was the average life expectancy of the inhabitants of the archaeological site?," etc.). These questions were based on the information that participants had been given (audio clips) while using the applications. Each correct answer received 1 point, while wrong answers received 0 points. The knowledge test was administered two times, one prior to participants' virtual exposure (preScore) and the second immediately after their virtual exposure (postScore). The specific questions included in the knowledge test can be found in Appendix C-1.

The response variable of interest Learning Performance was the difference between the two (dScore = postScore – preScore), which shows the degree of improvement (positive values) or decline (negative values) in score after exposure.

Table 15: The questionnaires given to participants.

Variable	Question
(a) Presence	
There	How much did you feel as if you were present at the archaeological site? (1. Not at all ... 5.Very much)
Reality	Were there moments during your experience that the virtual world became the reality for you, and you almost forgot about the real world where the study took place. (1.Never ... 5.All the time)
Place	Did you have stronger the feeling that you were in the real world of the laboratory or at the virtual Choirokoitia? (1.Laboratory ... 5.Choirokoitia)
(b) User Experience	
Image	How do you rate the image quality? (1.Very bad ... 5.Excellent)
Audio	How do you rate the audio quality?

	(1.Very bad ... 5.Excellent)
Pleasure	How pleasant did you find the experience? (1.Very unpleasant ... 5.Very pleasant)
Repeat	Would you like to try a similar experience in the future? (1.Not at all ... 5.Very much)
(c) Attitudes	
VisitChoirokoitia	Do you wish to visit the Choirokoitia site in the future? (1.Not at all ... 5.Very much)
VisitSites	Do you wish to visit any other archaeological sites in the future? (1.Not at all ... 5.Very much)
LearnChoirokoitia	Do you wish to learn more about the site of Choirokoitia? (1.Not at all ... 5.Very much)
LearnArchaeology	Do you wish to know more about the archaeology of Cyprus? (1.Not at all ... 5.Very much)

6.2.8 Procedure

Upon arriving at the laboratory, and after completing the consent form, participants were randomly assigned to the VR or the Desktop group and were asked to complete the Knowledge and Attitudes questionnaires alongside some demographic questions. Once this process was completed, participants in the VR group were asked to put on the VR HMD (Figure 41, left), and participants in the Desktop group were asked to sit in front of the computer screen (Figure 41, right). Then, both groups were instructed to follow the respective tutorial instructions in order to become familiar with the use of the corresponding system and application. Once the tutorial was completed (with an approximate duration of 5 min), the main experimental session began, which lasted ~8 min for both groups. After completing their navigation within virtual Choirokoitia, the participants of both groups again completed the Knowledge and Attitudes questionnaires and filled in the User Experience and Presence questionnaires.

Figure 41: Participants using the VR Application (left) and Desktop Application (right).

6.2.9 Statistical Analysis

For the questionnaire data on Presence, User Experience, and Attitudes (Table 15), factor analysis was carried out to reduce the number of questionnaire variables. This method also has the advantage of transforming ordinal variables into continuous ones.

Corresponding factor scores were used, and the interpretation of each factor was identified. For factor analysis on ordinal variables, such as in our case, Polychoric PCA analysis can be used as a test (this treats ordinal variables as if they were derived from cut-offs sampled from a normally distributed variable) (Olsson, 1979) and scores derived from those, so this approach was employed.

Box plots of all raw questionnaire scores are provided in Appendix C-2. Subsequent analysis of the derived variables was done using independent samples t-test. All results were obtained with the SPSS software.

6.3 Results

The means, standard errors and the p-values for the outcome variables; dScore, dAttitudes, Presence and User Experience by condition (VR and Desktop) are summarized in Table 16.

Table 16: Means, and standard error and p-values for all outcome variables for both groups.

Measures	Condition				
	VR		Desktop		p-values
	Mean	**SE**	**Mean**	**SE**	
dScore	1.35	0.386	2.5	0.336	p = 0.031
dAttitudes	0.013	0.102	−0.013	0.141	p = 0.88
Presence	0.59	0.098	−0.59	0.148	p = 0.000
User Experience	0.394	0.172	-0.394	0.238	p= 0.0108

SE=Standard error

6.3.1 Attitudes Analysis

The attitudes questionnaire was administered before and after the participants' experience. Factor analysis on the questions (Table 15c) resulted in a single factor, and the factor loadings on the scoring variables preAttitudes and postAttitudes, respectively, are shown in Tables 17, 18. The factors are explained by VisitSites, VisitChoirokoitia, LearnArchaeology, and LearnChoirokoitia (Table 15) and are interpreted as participants' "interest in acquiring new historical knowledge in the future."

Table 17: Factor analysis for participants' attitudes before the experience resulting in a single factor F1, and the scoring coefficients for the factor score preAttitudes

Variable	Factor Loadings	Scoring Coefficients
	F1	preAttitudes
VisitSites	0.844	0.272
VisitChoirokoitia	0.927	0.299
LearnArchaeology	0.940	0.303
LearnChoirokoitia	0.802	0.259

Table 18: Factor analysis for participants' attitudes after the experience resulting in a single factor F1, and the scoring coefficients for the factor score postAttitudes

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**postAttitudes**
VisitSites	0.835	0.263
VisitChoirokoitia	0.931	0.293
LearnArchaeology	0.940	0.296
LearnChoirokoitia	0.856	0.269

We investigated whether participants' attitudes toward archaeology were affected by the use of the VR and Desktop Applications. The variable of interest, dAttitudes = postAttitudes – preAttitudes, reflects the degree of change in attitudes regarding acquiring new knowledge in the future (positive values). Figure 42 shows the bar chart of the means and standard errors of dAttitudes, derived as the difference from the factor scores preAttitudes and postAttitudes. Although it can be seen that there is a slight positive change for the VR condition (M=0.013, SE=0.102) and a negative change for the Desktop condition (M=−0.013, SE=0.141), the differences between the two groups are not significant [t(38) = −0.151, p = 0.88].

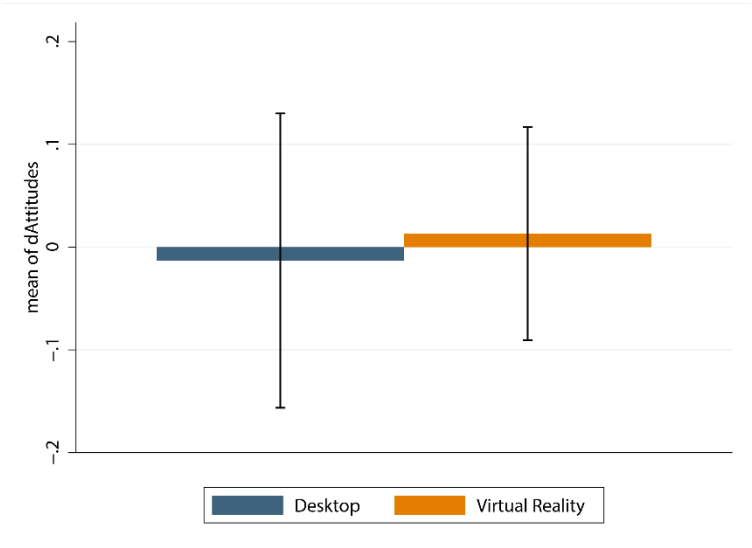


Figure 42: Bar chart showing mean and standard error of dAttitudes by condition.

6.3.2 Presence Analysis

A single factor was retained in the case of Presence (Table 15a), and the factor loadings on the scoring variable (Presence) are shown in Table 15. In the interpretation of the factor loadings, these capture the amount of overall variance in the observed variables. The scoring coefficients are the coefficients of the equations describing the factor scores in terms of a linear combination of the original variables. In Table 19, F1 is explained by “There, Reality, and Place”, which is reflected in the corresponding scoring coefficients for Presence. The latter interprets this factor as “the illusion of being at the archaeological site of Choirokoitia instead of in the physical laboratory.”

Table 19: Factor analysis for presence resulting in a single factor F1, and the scoring coefficients for the factor score *Presence.*

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**Presence**
There	0.937	0.356
Reality	0.926	0.352
Place	0.946	0.360

Figure 43 shows the bar chart of the means and standard errors of the derived factor analysis variable Presence. Participants in the VR condition felt a stronger sense of “being” at the archaeological site of Choirokoitia (M=0.59, SE=0.098) compared to participants in the Desktop condition (M=−0.59, SE=0.148). An independent samples t-test showed that the above differences are significant [t(38) = −4.712, p = 0.000].

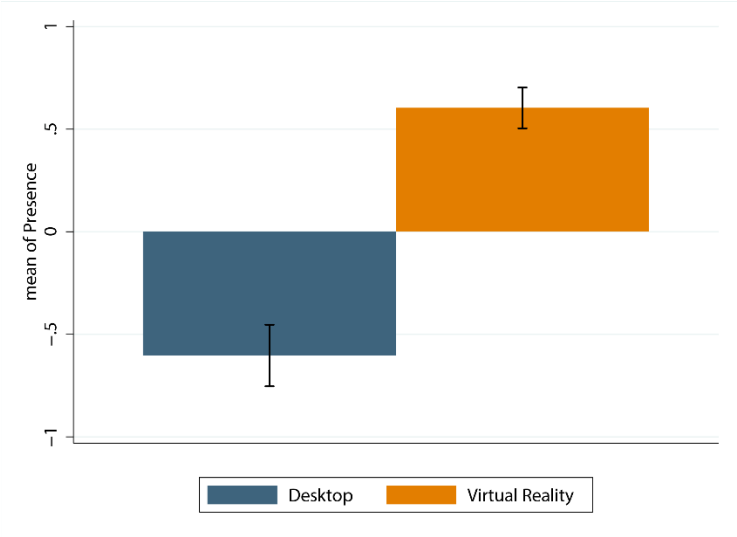


Figure 43: Bar chart showing means and standard errors for the factor score *Presence* by condition.

6.3.3 User Experience Analysis

Figure 44 shows the bar chart of the means and standard errors of the derived factor score UserExperience. Participants in the VR condition rated the overall experience of using the application more positively (M=0.394, SE=0.172) compared to participants in the Desktop condition (M=−0.394, SE=0.238). An independent samples t-test showed that the above differences are significant [t(38) = −2.6809, p= 0.0108].

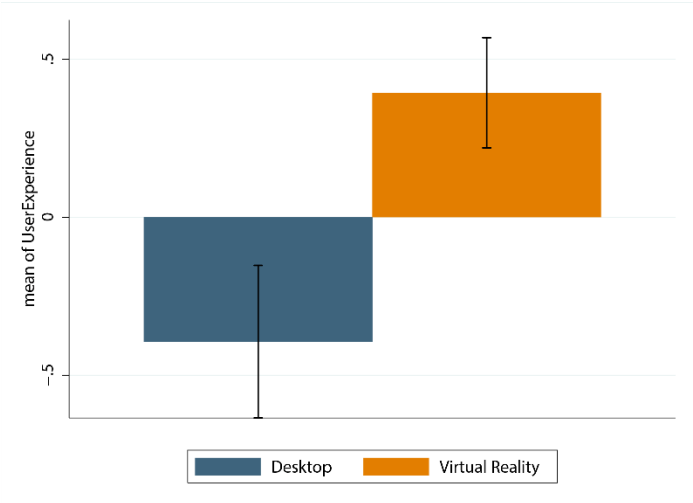


Figure 44: Bar chart showing means and standard errors for the factor score UserExperience by condition.

6.3.4 Learning Performance Analysis

The User Experience questions (Table 15b) resulted in a single factor, and the factor loadings on the scoring variable UserExperience are shown in Table 20. This factor is explained by Pleasure, Image, Audio, and Repeat, which is interpreted as "the level of pleasantness of the experience."

Table 20: Factor analysis for user experience resulting in a single factor F1, and the scoring coefficients for the factor score *UserExperience.*

Variable	**Factor Loadings**	**Scoring Coefficients**
	F1	**UserExperience**
Pleasure	0.854	0.299
Image	0.924	0.324
Audio	0.772	0.270
Repeat	0.824	0.288

The response variable of interest here is dScore = postScore – preScore, showing the degree of improvement (positive values) or decline (negative values) in score. The score is defined as the total number of correct responses to the knowledge questionnaire before and after the exposure. Figure 45 shows that the mean change in dScore was greater in the Desktop than in the VR condition. The means and standard errors are 2.5 ± 0.336 and 1.35 ± 0.386, respectively, with Cohen's d = 0.71, which is a medium to large effect size. An independent samples t-test showed a significant difference between the means $t(38) = 2.247$, $p = 0.031$. The residual errors are compatible with normality (Shapiro-Wilk P = 0.35).

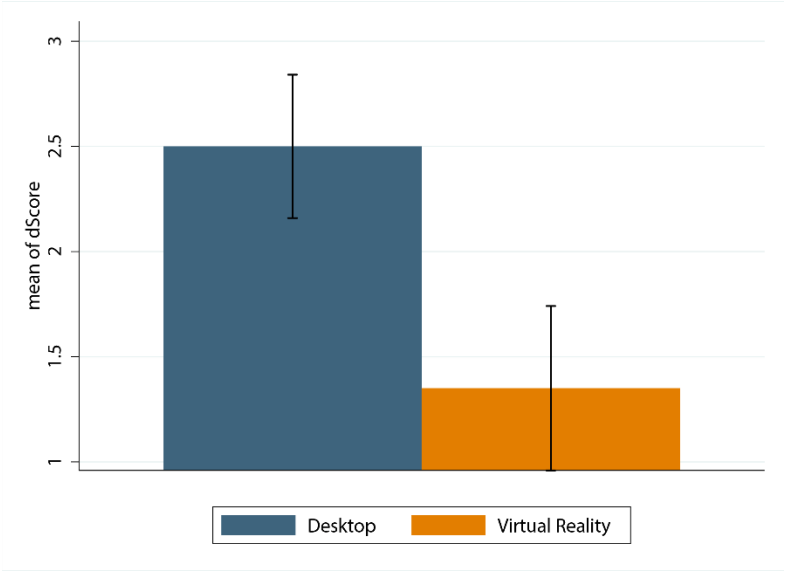


Figure 45: Bar chart showing mean and standard error of dScore by condition.

6.3.5 Correlations

Finally, we performed a Pearson's correlation analysis in order to explore relationships between the data collected. The correlations for the Desktop and the VR condition are summarized in Appendix C-3.

The sense of Presence strongly correlated with User Experience in both the Desktop [$r(18) = 0.83$, $p < 0.001$] and VR [$r(18) = 0.836$, $p < 0.001$] conditions. This result means that participants who reported a higher sense of Presence in the virtual environment also reported a higher level of UserExperience (how positively they rated the overall experience of using the application).

Presence is correlated with preScore in the Desktop condition [$r(18) = 0.61$, $p < 0.004$]. Also, in the Desktop condition, Presence correlated with preAttitudes [$r(18) = 0.561$, $p = 0.01$] and postAttitudes [$r(18) = 0.619$, $p = 0.004$]. UserExperience and preScore were correlated in the Desktop condition [$r(18) = 0.606$, $p = 0.005$]. Finally, UserExperience correlated with preAttitudes [$r(18) = 0.491$, $p = 0.028$] and postAttitudes [$r(18) = 0.569$, $p = 0.009$] in the VR condition.

6.4 Conclusions – Study 3

In this study, an effort was made to change peoples' cognitive attitudes about an archaeological site in Cyprus.

A study was conducted to examine whether the use of a VR-based simulation can change peoples' cognitive attitudes about an archaeological site more effective than a more traditional method. For this reason, we virtually reconstructed the archaeological site of Choirokoitia, developed and compared two applications, an immersive VR Application and a Desktop Application.

First, it was found that the VR Application has a critical advantage in terms of the sense of presence delivered to participants, which refers to the sense of "being there" in the virtual world (here, the virtual Choirokoitia) (Slater and Sanchez-Vives, 2016). The VR Application succeeded in giving participants the feeling of virtually visiting the archaeological site of Choirokoitia, more so than the Desktop Application, and it was also found that the overall user experience was significantly better in terms of image and audio quality, overall pleasantness, and willingness to try a similar application in the future.

However, the results demonstrated no advantage of the VR Application regarding participants' attitudes toward archaeology. The use of the VR Application did not seem to impact participants' motivation to acquire new knowledge in the future more than the Desktop Application. Furthermore, the VR Application was found to be less effective in acquiring and memorizing new information about the archaeological site. Interestingly, participants in the Desktop group gained more knowledge than the participants in the VR group.

This VR Application of Choirokoitia attempted to provide the best possible representation of the archaeological site, giving the user an experience that simulates a physical visit. The reconstruction used in this paper represents the current state of the archaeological site. But this reconstruction only exploits a part of the possibilities of VR technologies. VR can overcome the boundaries of reality, time, and space. For instance, users could experience "being" in the Choirokoitia of the Neolithic period, when the settlement was inhabited. Such an application would give the user visual information on how the settlement looked and the way of life and occupations of the inhabitants. This

paper has examined whether VR can enhance and promote archaeological content in comparison to a non-immersive medium. Although VR seems to have an advantage in terms of Presence and User Experience, regarding Learning Performance, new ways to convey information to the users should be explored. More importantly, users should be able to interact with the virtual environment and make the learning process active, rather than passive. According to the constructivism learning theory (Bada and Olusegun, 2015), learns construct knowledge in an active way, rather than passively taking in information. So interactivity and making users a part of the learning process in VR, could be utilized in future studies.

According to Tost and Economou (2009) and Roussou (2002), in order to be suitable for learning, cultural heritage virtual worlds should not just be visually represented in a photorealistic manner; they need to be complete, interactive and present the virtual world in a meaningful and engaging way. In this application, the information that the knowledge test was based on was conveyed using audio. It is possible, that the participants in the VR group, overwhelmed by the technology, paid less attention to the audio information, and this might explain their lower increase in learning performance. Therefore, in future studies, a Neolithic- period Choirokoitia application in which the information would be rendered mainly visually could overcome the limitation of knowledge transfer.

7 Conclusions

This chapter presents conclusions that were derived from the findings of this dissertation. It later presents the contribution of the research and the limitations that the three studies had. Moreover, it presents the future direction of this work and new research ideas and techniques that could be used in future applications.

7.1 Summary

This dissertation aimed to evaluate the use of VR for changing peoples' attitudes, in order to modernize the methods used so far by social professionals and make them more engaging.

VR was chosen as a medium because its transformative power is allowing people to view the perspective of other people or transfer them into imaginary places and scenarios, where they can learn and take the part of another person. These aspects make it a medium that can help in the effort to bring attitude change.

Through the years, people have tried many technologies, from advertisements on TV, through articles in newspapers, documentaries, and visits to schools to achieve attitude change. People stuck in their everyday life routines, do not have the leisure of time to travel and visit sites in other countries, or even their own country, and learning about cultures and archaeological sites is often made in school using books and images. Regarding substance use from students inside the school perimeter, there is a lack of teacher preparation in case they face such an incident, and a lack of empathy from the teachers toward students facing such issues. Even everyday people, have preconceived beliefs about drug users and the reasoning for their acts, ultimately leaving drug users being discriminated against in their efforts to re-enter society and live a normal life.

The first two studies dealt with changing affective attitudes toward stigmatized groups and more specifically drug users. The first study of the dissertation (Christofi et al., 2018), by using VR based methodology, allowed teachers to put themselves in the position of a student that faces substance use problems in the school environment, in order to change their affective attitudes like empathy toward them.

The second study (Christofi & Michael-Grigoriou, 2020) compared a VRPT system that supported a number of sensorimotor contingencies (SC condition) and a less immersive perspective-taking system using a desktop computer with a minimum support of sensorimotor contingencies (NSC condition), to investigate their effect changing affective attitudes like empathy toward drug users.

The third study (Christofi et al., 2018, Kyrlitsias, Christofi, Michael-Grigoriou, Banakou & Ioannou, 2020), dealt with changing peoples' cognitive attitudes toward an archaeological site in Cyprus. A study was conducted to examine whether the use of a VR-based simulation can change peoples' cognitive attitudes about an archaeological site more effective than a more traditional method.

7.2 Reflections with regards to the research questions

7.2.1 RQ1: Do different perspectives change the affective attitudes of teachers toward drug users in a school through a virtual school environment?

Regarding empathy findings showed no difference between the two groups in their empathy. The only significant difference was found in the reversed item "I find it difficult to relate with students going through drug problems" in the TSDU group. The results show that the participants tended to be more neutral regarding the sense of embodiment, no matter their group, according to their median scores.

Overall, it was shown that the use of the VR system elicited a statistically significant change in the participant's negative mood states. The only significant difference between the two groups was found in participants of the TSDU group that were found significantly more downhearted than those in the TSO group after the VR experience.

Previous research by Kim et al. (2014) revealed that the HMD system elicited higher levels of negative emotions than the desktop platform. 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 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. Regarding the change in perspective,

Gonzalez-Liencres et al.'s (2020) study, explored the impact of an immersive virtual scene of intimate partner violence experienced from the victim's perspective (first person), as opposed to witnessing it as an observer (third person). The first-person perspective helped participants to take the scene personally, and it generated a sensation of fear, helplessness, and vulnerability, and tended to induce greater behavioral and physiological reactions.

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. Regarding heart rate, the results indicate a significant difference before and after the VR experience for all the participants and for the TSDU group as well.

It is possible that the scenario which was related to substance use might have affected the participants. Another possible explanation for the increase of participant's HR might be related to the use of the VR headset, Oculus Rift. Available reports of previous research concerning HR changes while using VR indicate participants' exposure to fear conditioning tasks within VR increased their HR and the increase was higher to the high symptom group than in the low symptom group (Roy et al., 2013). In the study by Malińska et al. (2015), the results also revealed that the HR of the participants who experienced the virtual world was higher than those who watched a stereoscopic movie. Guger et al. (2004) found that participant's HR decreased in time from the moment the participants were exposed to the training phase so as to be familiar with the virtual world until the experiment phase. The study also revealed that participant's HR increased after a conversation with the avatars. Furthermore, research by Ding et al. (2018) also revealed that HR was higher in the group that used VR.

Regarding the impact of the different perspectives that the participants experienced the levels of presence, the results of the questionnaire did not confirm a statistically significant difference. However, it should be noted that the post-questionnaire that included the presence questionnaires was given after the completion of the experiment and the experience of both perspectives. As a result, the possible change between the perspectives would be difficult to be recorded within the questionnaire.

Overall, this study showed some signs that the different perspectives had an impact on their affecting attitudes, but more research is needed.

7.2.2 RQ2: Do sensorimotor contingencies supported by a VR system, change the affective attitudes induced toward drug users?

Results showed that the SC group had higher means in all the measures, but they were not significantly different from those of the NSC group. Both groups showed a significant difference in their reported attitudes toward drug users before and after their exposure, which means that both interventions succeeded in eliciting more positive attitudes toward drug users to the participants.

Participants in the SC group reported significantly higher levels of PI, BOA, and PVP but not the Situation. The SC groups' higher levels of empathy and body ownership could explain the correlation between their closeness to the drug user and empathy as well as their positive attitudes toward drug users.

This study showed some signs that sensorimotor contingencies supported by a VR system, can change the affective attitudes induced toward drug user. The SC group had overall higher scores in the measures, but ultimately, they were not shown significantly different than those in the NSC group.

7.2.3 RQ3: Can the use of a VR-based simulation change peoples' cognitive attitudes about an archaeological site?

The results demonstrated no advantage of the VR Application regarding participants' attitudes toward archaeology. The use of the VR Application did not seem to impact participants' motivation to acquire new knowledge in the future more than the Desktop Application.

Furthermore, the VR Application was found to be less effective in acquiring and memorizing new information about the archaeological site. Interestingly, participants in

the Desktop group gained more knowledge than the participants in the VR group, aligning with previous studies that showcased that indeed, immersive VR technologies can have an overwhelming impact on participants (Van der Heijden, 2004; Freina and Canessa, 2015), leading to diminished attention and a lower increase in their learning performance. Previous studies have shown that low-immersion simulations, such as computer games and other desktop applications, can result in better cognitive performance and attitudes toward learning (Bonde et al., 2014; Clark et al., 2016; Makransky et al., 2016; Thisgaard and Makransky, 2017). However, research evidence as to whether high-immersive virtual reality applications lead to increased motivational outcomes and learning is still controversial.

In the study described in Passig et al. (2016), the authors showed that teaching in immersive VR environments contributed to students' cognitive modifiability more than traditional learning experiences. Similar results were reported by Alhalabi (2016) when using a VR system to enhance students' education in engineering, and by Webster (2016) when aiming to improve learning on basic corrosion prevention and control in military personnel. In contrast, other studies have yielded negative results when comparing learning in immersive VR environments and desktop applications. In one example, Moreno and Mayer (2002) investigated how desktop VR and immersive VR, the second using an HMD and navigation techniques, compared with multimedia learning material. It was found that the two media did not affect students' performance differently, with equal improvement results for both. Similarly, Richards and Taylor (2015) found that biology students' knowledge did not improve after exposing them to virtual simulations with 3D models more than with simulations using two-dimensional (2D) models. The authors concluded that this could have occurred due to the additional cognitive load imposed by the 3D models. Likewise, in previous research comparing an immersive VR human anatomy application with traditional slide presentations, it was found that although both methods increased participants' performance, this was higher for participants in the slide-presentation group ((Michael-Grigoriou, D., Yiannakou, P. & Christofi, M, 2017).

The present results are in line with the aforementioned studies, showcasing that indeed, immersive VR technologies can have an overwhelming impact on participants, leading to diminished attention and a lower increase in their learning performance. According to

the cognitive load theory (CLT), if one engages in excessive amounts of extraneous processing (i.e., cognitive processing that does not support the goal, caused for instance by distractions), then there is not an adequate capacity for critical processing and thus meaningful learning outcomes (Sweller, 1994). Additionally, Thisgaard and Makransky (2017) suggest that highly immersive environments might not necessarily result in higher learning and transfer outcomes due to their highly hedonic or utilitarian nature. According to this theory, fun or pleasurable experiences within immersive VR environments can lead users to disregard their instrumental value, and instead, concentrate on the entertainment value such systems offer.

Based on the above and in line with previous studies, it is speculated that something similar happened in the present study, with participants in the VR group spending more time exploring and navigating through the new (to them) immersive environment, thus leading to poor attention to other stimuli and consequently, worse performance in the knowledge test. This has been previously supported in the context of immersive virtual gaming apps, where the authors explain that navigation through virtual rooms can draw attention away from the main task and negatively influence players' learning (Freina and Canessa, 2015). Further, and according to Van der Heijden (2004), it could be argued that participants focused more on enjoying the environment rather than on learning the material presented to them. It is now known, however, how performance would have been affected if the participants had had more experience in using VR environments.

In this study, all participants had little or no prior knowledge of VR systems, and therefore, this point cannot be addressed here, but we leave it as an open question for further research. Also, regarding motivation, it should be noted that participants in both experimental groups reported positive attitudes toward archaeology even before their virtual exposure, which could possibly explain why there were no differences in attitudes after the exposure. Further, attitudes and motivation were based on self-reported questionnaires, which are oftentimes subject to social desirability bias (Yu, Shen & Smith, 2018).

7.3 Contributions

The results of this thesis will contribute to the attitude change scene, and hopefully make social professionals previously sticking to using traditional methods of researching such issues, to modernize their approaches and make them more engaging.

Regarding to VR's effectiveness to bring affective and cognitive attitudes change in people, potential was found based on the findings, although no significant changes were found between the groups that were compared were found.

Results from the three studies conducted showed the potential of using VR as a more engaging and immersive medium for attitude change. The VR applications made in Studies 2 and 3 were found to elicit a higher level of presence in participants than their traditional counterparts. The traditional method of learning in Study 3 was found more effective in cognitive attitude change than the VR application, which although it was in line with previous research, shows that new ways need to be found to make VR applications more effective in transferring knowledge to people.

Findings in this thesis have highlighted some design elements that seemed effective in attitude change and can be suggested to the academic community for meeting similar research objectives in future studies. Putting the participants in the viewing perspective of the member of the stigmatized group, in Experiment 1, seemed to have the most effect, so it is a crucial perspective that the participants have to witness in order to change their attitudes for that stigmatized group. Moreover, the use of VR was also found to make the participants report more present in the virtual world, in Experiments 2 and 3. Participants in the Sensorimotor Contingencies group in Experiment 2 also felt more that the virtual people were real, so real time full body tracking can be also suggested.

7.4 Limitations

As with any research, this also had several limitations that could have impacted the results. The number of participants is a factor. Study 1 collected data with a relatively small sample of educators, therefore results can only be seen as a first attempt and therefore should not be generalized. We did not show that perspective taking had a

significant effect on participants empathy, based on the group differences in dEmpathy. However, we can not support the null hypothesis due to the small sample size.
Another limitation of the study was the target group. As it was shown, teachers are a hard group to approach due to their limited availability, and also that most of them are skeptical about the use of technologies, as they were not familiar with any of them, which definitely impacted the results of Study 1. The EEG use in the first study was a challenge as well, as some of the teachers were negative toward its use on their head, because they thought it was dangerous. This applied as well for the fitness tracker. They were reassured of their safety and that they could quit the study at any time. Even though there are several trustworthy and validated empathy scales, none of them was designed to address the cultivation of empathy skills through VR intervention. Additionally, the fact that the used scale was based on several items from other scales could also have affected the results.

A limitation of Study 2 was the use of questionnaires only for the measures. As the participants in the SC group of that study were wearing a full body suit and VR gloves for their real-time body tracking, there was no place to put additional devices like a fitness watch for the measurement of their heart rate.

In Study 3, the information that the knowledge test was based on was conveyed using audio. It is possible, that the participants in the VR group, overwhelmed by the technology, paid less attention to the audio information, and this might explain their lower increase in learning performance. A limitation of this study is that there are differences not only in the technology used in the two groups (VR vs. Desktop) but also in the features of the applications as such. For example, the VR Application offers the user the possibility to freely navigate in a 3D environment, while the Desktop version provides the visual information in 2D renders. While this simplification on the Desktop Application was intentional, as it allows its development by people with basic computer skills, it does not allow us to safely attribute the differences we detected between the VR group and Desktop group either to the type of technology used (immersive or not) or to the application as such. For example, the VR Application offered the user the possibility to freely navigate in a 3D environment, while the Desktop version provided the visual information in 2D renders.
To conclude, several limitations occurred during this dissertation as it happens to

every study and research. It should be noted that the researcher made sure to minimize the impact of those limitations in the studies.

7.5 Future work

The results of this research revealed the potential of using VR technologies to modernize the attitude change methods used so far by social professionals.

Using feedback that was received by participants of the studies, the development of new scenarios or the expansion of the current ones is definitely a future priority. There are several groups of people that have not been a focus of research in a VR context at all or have been but very little. One example is the members of the LGBTQ+ community, as it seems that it is a group that has not been studied as much as it should. Only one study currently exists by Roel Lesur, Lyn, and Lenggenhager, (2020), in which participants embodied a transgender man who was narrating his life. Other groups are former prison inmates, who often find it hard to come back to society and find a job since they are discriminated against. Additionally, in the scenarios, more focus should be made on the negative aspects and effects that discrimination brings to those stigmatized members and their life.

From a technical standpoint, interaction with the application and the other virtual humans in the world is definitely required for future studies, as it was missing from the studies in this dissertation. Interactivity has been found to increase empathy (Vorderer, Knobloch & Schramm, 2001), and it can be utilized in future VR applications. The virtual humans could also have an increased Artificial Intelligence (AI), so that they could react real-time to the users' actions.

As many companies are releasing VR headsets every year with way more features and less required equipment to allow hands and even body tracking, it would be also interesting to compare in future studies, the difference between low vs. high cost VR and tracking equipment in the supporting sensorimotor contingencies. Examples of that could include the comparison of motion tracking technologies like the more affordable Microsoft Kinect and a more expensive specialized motion tracking suit like the one used by the participants of the SC group in the current study, or even different cost HMDs, which offer less or more tracking possibilities.

If its decided to make these applications available to social professionals at some point, perhaps it would be best if special versions could be developed for smartphones, so that these people will only need to acquire a low-cost VR headset to be able to run the application. If this happens, then the application could be translated to other languages too, as it currently is available in English only.

An interesting area to study is to examine how the attribution of responsibility can modulate an observer's emotional response toward such stigmatized targets. Decety, Echols, & Correll in their 2010 study wanted to examine the effect of responsibility and social stigma on empathy for pain. The more the participants blamed the stigmatized targets, the less pain the participants attributed to the stigmatized targets, compared to healthy controls. It would be interesting for people to be put in a position of judgment on whether a prisoner was wrongfully convicted or not for their crime, based on the prisoners' perspective, and how that experience could affect people's opinions and attitudes toward that prisoner.

In Study 3, the VR application featured the archaeological site as it stands today. It would be interesting to make an alternative version where such an application would give the user visual information on how the settlement looked and the way of life and occupations of the inhabitants. Therefore, in future studies, a Neolithic- period Choirokoitia application, in which the information would be rendered mainly visually, could overcome the limitation of knowledge transfer. Additionally, future studies should look at alternative and more indirect ways of measuring motivation, such as, for example, follow-up forum access and participation related to activities on the given subject (either on the same day or in the long-term).

Some focus should also be given the behavioral attitude changes that the VR applications could induce, as the current studies only the other two types of empathy, affective and cognitive. As Myers (2010) states, "Our private beliefs and feelings determine our public behavior, so if we wish to change behavior, we must first change hearts and minds." So, another point to consider is investigating whether the results of the study last over time because no follow-up measurements were carried out in any of the studies. In the case of future applications that have more interaction between the user and virtual humans, the participants' body language and real-time behavior could also be investigated. Implicit proxemic indicators of attitudes like the participants'

interpersonal distance, head orientation and personal space between them and other avatars in the virtual world could also be recorded easily in future applications and give more information about the participants' attitudes.

As far as the measurements used in this dissertation, mostly self-report instruments were utilized with the exception of the EEG and heart rate in Study 1. In Study 2, for the measurement of empathy, self-report questionnaires were used. Questionnaires in general, can be biased, as participants can lie, give their own subjective answer, or answer in a way that they think will favor the research of the researcher. Future studies and efforts should utilize more behavioral methods for the measurement of empathy like recording the actions and movements of the participants in the virtual world and their interactions within it and coding them to a level of an attitude. Another way is putting choices for the participant in their virtual experience, and depending on their choice, it can give indications about their implicit attitudes. One example of this could be to give the participant the choice in the virtual environment to help or save a person in need. Another way is to measure how close they choose to stand near a member of a stigmatized group, and whether they choose to look at that person, and for how long.

Other methods that should be used more are neuroscientific methods, like one of the famous techniques to study brain activity; EEG (Electroencephalography), which records the brain's electrical activity. Another technique that could be used is to record the eye movement of the participants which could really be useful in VR studies, with specific HMD's that offer this feature. This can give insight for where the participant is looking when a certain event is happening in the virtual world. This technique or similar ones can also record emotions which can help in the measurement of attitudes more accurately than the subjective answer of a participant in a questionnaire.

7.6 Concluding remarks

This dissertation aimed to evaluate the use of VR for changing peoples' attitudes, in order to modernize the methods used so far by social professionals and make them more engaging.

Results from these studies show the potential of VR as a medium for attitude change and more specifically for affective attitudes and more specifically inducing empathy for drug users and positive attitudes for them. VR-based methods did not significantly increase knowledge or a change in attitudes towards an archaeological site. Findings showed that more research is needed regarding what could make VR-based methods more effective for bringing cognitive attitude change like knowledge acquisition, with promising results in inducing empathy for stigmatized groups.

VR and its transformative power are allowing people to view the perspective of other people or transfer them into imaginary places and scenarios where they can learn and take the part of another person. These aspects make it a medium that can help in the effort to bring a change in peoples' attitudes.

The results of this thesis added more into attitude change research scene, and it will hopefully make social professionals, previously sticking to using traditional methods of attitude modernize their approaches and make them more engaging and reach out to VR developers and researchers for joining their forces and knowledge to create VR experiences that will bring some change.

REFERENCES

Ahn, S. J., Bostick, J., Ogle, E., Nowak, K. L., McGillicuddy, K. T., & Bailenson, J. N. (2016). Experiencing nature: Embodying animals in immersive virtual environments increases inclusion of nature in self and involvement with nature. *Journal of Computer-Mediated Communication*, *21*(6), 399-419. https://doi.org/10.1111/jcc4.12173

Ahn, S. J., Le, A. M. T., & Bailenson, J. (2013). The effect of embodied experiences on self-other merging, attitude, and helping behavior. *Media Psychology*, *16*(1), 7-38. https://doi.org/10.1080/15213269.2012.755877

Alhalabi, W. (2016). Virtual reality systems enhance students' achievements in engineering education. *Behaviour & Information Technology*, *35*(11), 919-925. https://doi.org/10.1080/0144929X.2016.1212931

Allcoat, D., & von Mühlenen, A. (2018). Learning in virtual reality: Effects on performance, emotion and engagement. *Research in Learning Technology*, *26*. https://doi.org/10.25304/rlt.v26.2140

Allport, G. W., Clark, K., & Pettigrew, T. (1954). The nature of prejudice.

Amnesty International. (2017). *Fear of the Sky*. Retrieved from http://www.360syria.com/intro

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, *63*(4), 596. https://doi.org/10.1037/0022-3514.63.4.596

Babbie, E. R. (1998). *The practice of social research*. International Thomson Publishing Services.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66-70. https://doi.org/10.9790/7388-05616670

Bailenson, J. N., Yee, N., Blascovich, J., Beall, A. C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital

transformations of teachers, students, and social context. *The Journal of the Learning Sciences*, *17*(1), 102-141. https://doi.org/10.1080/10508400701793141

Baka, E., Stavroulia, K. E., Magnenat-Thalmann, N., & Lanitis, A. (2018). An EEG-based evaluation for comparing the sense of presence between virtual and physical environments. In *Proceedings of Computer Graphics International 2018* (pp. 107-116). https://doi.org/10.1145/3208159.3208179

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*, *53*(1), 86-107. https://doi.org/10.1007/BF02504859

Batson, C. D. (2009). *These things called empathy: Eight related but distinct phenomena.* In J. Decety & W. Ickes (Eds.), *Social neuroscience. The social neuroscience of empathy* (p. 3–15). MIT Press. https://doi.org/10.7551/mitpress/9780262012973.003.0002

Batson, C. D., Early, S., & Salvarani, G. (1997). Perspective taking: Imagining how another feels versus imaging how you would feel. *Personality and Social Psychology Bulletin*, *23*(7), 751-758. https://doi.org/10.1177/0146167297237008

Batson, C. D., Lishner, D. A., Carpenter, A., Dulin, L., Harjusola-Webb, S., Stocks, E. L., ... & Sampat, B. (2003). "... As you would have them do unto you": Does imagining yourself in the other's place stimulate moral action?. *Personality and Social Psychology Bulletin*, *29*(9), 1190-1201. https://doi.org/10.1177/0146167203254600

Batson, C. D., Polycarpou, M. P., Harmon-Jones, E., Imhoff, H. J., Mitchener, E. C., Bednar, L. L., ... & Highberger, L. (1997). Empathy and attitudes: Can feeling for a member of a stigmatized group improve feelings toward the group?. *Journal of Personality and Social Psychology*, *72*(1), 105. https://doi.org/10.1037/0022-3514.72.1.105

Baumgartner, T., Valko, L., Esslen, M., & Jäncke, L. (2006). Neural correlate of spatial presence in an arousing and noninteractive virtual reality: an EEG and psychophysiology study. *CyberPsychology & Behavior*, *9*(1), 30-45. https://doi.org/10.1089/cpb.2006.9.30

Behm-Morawitz, E., Pennell, H., & Speno, A. G. (2016). The effects of virtual racial embodiment in a gaming app on reducing prejudice. *Communication Monographs*, *83*(3), 396-418. https://doi.org/10.1080/03637751.2015.1128556

Bertrand, P., Guegan, J., Robieux, L., McCall, C. A., & Zenasni, F. (2018). Learning empathy through virtual reality: multiple strategies for training empathy-related abilities using body ownership illusions in embodied virtual reality. *Frontiers in Robotics and AI*, 5, 26. https://doi.org/10.3389/frobt.2018.00026

Bevans, R. (2020, August 04). A Quick Guide to Experimental Design: 4 Steps & Examples. Retrieved November 12, 2020, from https://www.scribbr.com/methodology/experimental-design/

Blascovich, J., & McCall, C. (2010). Attitudes in virtual reality. *The Psychology of Attitudes and Attitude Change*, 283-297.

Bonde, M. T., Makransky, G., Wandall, J., Larsen, M. V., Morsing, M., Jarmer, H., & Sommer, M. O. (2014). Improving biotech education through gamified laboratory simulations. *Nature Biotechnology*, *32*(7), 694-697. https://doi.org/10.1038/nbt.2955

Botella, C., Fernández-Álvarez, J., Guillén, V., García-Palacios, A., & Baños, R. (2017). Recent progress in virtual reality exposure therapy for phobias: a systematic review. *Current Psychiatry Report*, *19*(7), 42. https://doi.org/10.1007/s11920-017-0788-4

Botvinick, M., & Cohen, J. (1998). Rubber hands ‘feel’ touch that eyes see. *Nature*, *391*(6669), 756–756. https://doi.org/10.1038/35784

Bouton, B., & Buxton, C. (2014). *Initial development and validation of the teacher Empathy Scale: TES* (Doctoral dissertation, University of Georgia).

Bujić, M., Salminen, M., Macey, J. and Hamari, J. (2020), "“Empathy machine”: how virtual reality affects human rights attitudes", *Internet Research*, Vol. 30 No. 5, pp. 1407-1425. https://doi.org/10.1108/INTR-07-2019-0306

Choirokoitia. Retrieved January 21, 2021, from http://whc.unesco.org/en/list/848

Christofi, M., Baka, E., Stavroulia, K. E., Michael-Grigoriou, D., Lanitis, A., & Magnenat-Thalmann, N. (2018). Studying levels of presence in a virtual

environment simulating drug use in schools: effect on different character perspectives. In *Proceedings of ICAT-EGVE 2018–28th International Conference on Artificial Reality and Telexistence (ICAT 2018) and the 23rd Eurographics Symposium on Virtual Environments (EGVE 2018), Limassol* (pp. 163-170). https://doi.org/10.2312/egve.20181329

Christofi, M., Kyrlitsias, C., Michael-Grigoriou, D., Anastasiadou, Z., Michaelidou, M., Papamichael, I., & Pieri, K. (2018). A Tour in the Archaeological Site of Choirokoitia Using Virtual Reality: A Learning Performance and Interest Generation Assessment. In: Ioannides M., Martins J., Žarnić R., Lim V. (eds) Advances in Digital Cultural Heritage. Lecture Notes in Computer Science, vol 10754. Springer, Cham. https://doi.org/10.1007/978-3-319-75789-6_15

Christofi, M., & Michael-Grigoriou, D. (2017, October). Virtual reality for inducing empathy and reducing prejudice towards stigmatized groups: a survey. In *2017 23rd International Conference on Virtual Systems & Multimedia (VSMM)* (pp. 1-8). IEEE. https://doi.org/10.1109/VSMM.2017.8346252

Christofi, M., Michael-Grigoriou, D., & Kyrlitsias, C. (2020). A Virtual Reality Simulation of Drug Users' Everyday Life: The Effect of Supported Sensorimotor Contingencies on Empathy. *Frontiers in Psychology*, *11*, 1242. https://doi.org/10.3389/fpsyg.2020.01242

Christofi, Stavroulia, K. E., M., Baka, E., Michael-Grigoriou, D., Magnenat-Thalmann, N., & Lanitis, A. (2021). Inducing empathy into teachers about substance users using a VR simulation.

Christoforou, M., & Michael-Grigoriou, D. (2015). Virtual worlds' influences on our mental balance and physical health: a survey with philosophical approaches.

Christou, C., & Michael, D. (2014, September). Aliens versus humans: Do avatars make a difference in how we play the game?. In *2014 6th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)* (pp. 1-7). IEEE. https://doi.org/10.1109/VS-Games.2014.7012029

Cimons, M. (2016, November 12). Using virtual reality to make you more empathetic in real life. *The Washington Post*. WP Company. Retrieved from https://www.washingtonpost.com/national/health-science/using-virtual-reality-to-

make-you-more-empathetic-in-real-life/2016/11/14/ff72ee7a-a06e-11e6-a44d-cc2898cfab06_story.html?utm_term=.284b068b7766

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research*, *86*(1), 79-122. https://doi.org/10.3102/0034654315582065

Clore, G. L., & Jeffery, K. M. (1972). Emotional role playing, attitude change, and attraction toward a disabled person. *Journal of Personality and Social Psychology*, *23*(1), 105. https://doi.org/10.1037/h0032867

Codd, A. M., & Choudhury, B. (2011). Virtual reality anatomy: Is it comparable with traditional methods in the teaching of human forearm musculoskeletal anatomy?. *Anatomical Sciences Education*, *4*(3), 119-125. https://doi.org/10.1002/ase.214

Cox, W. T. L., Abramson, L. Y., Devine, P. G., & Hollon, S. D. (2012). Stereotypes, Prejudice, and Depression. *Perspectives on Psychological Science*, *7*(5), 427–449. https://doi.org/10.1177/1745691612455204

Crandall, C. S. (1995). Do parents discriminate against their heavyweight daughters?. *Personality and Social Psychology Bulletin*, *21*(7), 724-735. https://doi.org/10.1177/0146167295217007

Crosier, J. K., Cobb, S. V., & Wilson, J. R. (2000). Experimental comparison of virtual reality with traditional teaching methods for teaching radioactivity. *Education and Information Technologies*, *5*(4), 329-343. https://doi.org/10.1023/A:1012009725532

Cummings, J. J., Tsay-Vogel, M., Cahill, T. J., & Zhang, L. (2021). Effects of immersive storytelling on affective, cognitive, and associative empathy: The mediating role of presence. New Media & Society. https://doi.org/10.1177/1461444820986816

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113. https://doi.org/10.1037/0022-3514.44.1.113

Draper, J. V., Kaber, D. B., & Usher, J. M. (1998). Telepresence. *Human factors*, *40*(3), 354-375. https://doi.org/10.1518/001872098779591386

De la Peña, N., Weil, P., Llobera, J., Giannopoulos, E., Pomés, A., Spanlang, B., ... & Slater, M. (2010). Immersive journalism: immersive virtual reality for the first-person experience of news. *Presence: Teleoperators and Virtual Environments*, *19*(4), 291-301. https://doi.org/10.1162/PRES_a_00005

Decety, J., Echols, S., & Correll, J. (2010). The blame game: the effect of responsibility and social stigma on empathy for pain. *Journal of Cognitive Neuroscience*, *22*(5), 985-997. https://doi.org/10.1162/jocn.2009.21266

Devine, P. G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology*, *56*(1), 5. https://doi.org/10.1037/0022-3514.56.1.5

Ding, N., Zhou, W., & Fung, A. Y. (2018). Emotional effect of cinematic VR compared with traditional 2D film. *Telematics and Informatics*, *35*(6), 1572-1579. https://doi.org/10.1016/j.tele.2018.04.003

Durbin, J. (2017, January 19). Vive To Spend $10 Million on VR Projects That 'Create Positive Impact'. *UploadVR*. UploadVR. Retrieved from https://uploadvr.com/vive-vr-for-impact-10-million/

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt Brace Jovanovich College Publishers.

Eckel, C., Grossman, P. J., & Milano, A. (2007). Is more information always better? An experimental study of charitable giving and Hurricane Katrina. *Southern Economic Journal*, 388-411. https://doi.org/10.2307/20111974

Eschenbrenner, B., Nah, F. F. H., & Siau, K. (2008). 3-D virtual worlds in education: Applications, benefits, issues, and opportunities. *Journal of Database Management (JDM)*, *19*(4), 91-110. https://doi.org/10.4018/jdm.2008100106

Ethics Unwrapped. (2019, April 11). *Fundamental Attribution Error*. Retrieved November 18, 2020, from https://ethicsunwrapped.utexas.edu/video/fundamental-attribution-error

European Monitoring Centre for Drugs and Drug Addiction (2017), *Cyprus, Country Drug Report 2017,* Publications Office of the European Union, Luxembourg

European Monitoring Centre for Drugs and Drug Addiction (2019), *Cyprus, Country Drug Report 2019,* Publications Office of the European Union, Luxembourg

European Monitoring Centre for Drugs and Drug Addiction (2020), European Drug Report 2020: Trends and Developments, Publications Office of the European Union, Luxembourg.

Farmer, H., Tajadura-Jiménez, A., & Tsakiris, M. (2012). Beyond the colour of my skin: How skin colour affects the sense of body-ownership. *Consciousness and Cognition*, *21*(3), 1242-1256. https://doi.org/10.1016/j.concog.2012.04.011

Fazio, R. H., & Olson, M. A. (2003). Implicit measures in social cognition research: Their meaning and use. *Annual Review of Psychology*, *54*(1), 297-327. https://doi.org/10.1146/annurev.psych.54.101601.145225

Felnhofer, A., Kothgassner, O. D., Schmidt, M., Heinzle, A. K., Beutl, L., Hlavacs, H., & Kryspin-Exner, I. (2015). Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International Journal of Human-Computer Studies*, *82*, 48-56. https://doi.org/10.1016/j.ijhcs.2015.05.004

Fernandes, A. S., & Feiner, S. K. (2016, March). Combating VR sickness through subtle dynamic field-of-view modification. In *2016 IEEE symposium on 3D user interfaces (3DUI)* (pp. 201-210). IEEE. https://doi.org/10.1109/3DUI.2016.7460053

Festinger, L. (1962). *A theory of cognitive dissonance* (Vol. 2). Stanford university press.

Four Walls: Inside Syrian Lives | Virtual Reality with Rashida Jones. (2017). *International Rescue Committee (IRC)*. Retrieved from https://www.rescue.org/four-walls

Fox, J., Bailenson, J., & Binney, J. (2009). Virtual experiences, physical behaviors: The effect of presence on imitation of an eating avatar. *Presence: Teleoperators and Virtual Environments*, *18*(4), 294-303. https://doi.org/10.1162/pres.18.4.294

Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine*, *47*(14), 2393-2400. https://doi.org/10.1017/S003329171700040X

Freina, L., & Canessa, A. (2015, October). Immersive vs desktop virtual reality in game based learning. In *European Conference on Games Based Learning* (p. 195). Academic Conferences International Limited.

Freina, L., & Ott, M. (2015, April). A literature review on immersive virtual reality in education: state of the art and perspectives. In *The International Scientific Conference ELearning and Software for Education* (Vol. 1, No. 133, pp. 10-1007).

Gallagher, S. (2000). Philosophical conceptions of the self: implications for cognitive science. *Trends in Cognitive Sciences*, *4*(1), 14–21. https://doi.org/10.1016/S1364-6613(99)01417-5

Galinsky, A. D., Maddux, W. W., Gilin, D., & White, J. B. (2008). Why It Pays to Get Inside the Head of Your Opponent. *Psychological Science*, *19*(4), 378–384. https://doi.org/10.1111/j.1467-9280.2008.02096.x

Gaumer Erickson, A.S., Soukup, J.H., Noonan, P.M., & McGurn, L. (2018). Self-Regulation formative questionnaire technical report. Retrieved from http://www.researchcollaboration.org/uploads/EmpathyQuestionnaireInfo.pdf

Gentile, D. A., Anderson, C. A., Yukawa, S., Ihori, N., Saleem, M., Ming, L. K., ... & Rowell Huesmann, L. (2009). The effects of prosocial video games on prosocial behaviors: International evidence from correlational, longitudinal, and experimental studies. *Personality and Social Psychology Bulletin*, *35*(6), 752-763. https://doi.org/10.1177/0146167209333045

Gilbert, D. T., & Malone, P. S. (1995). The correspondence bias. *Psychological Bulletin*, *117*(1), 21. https://doi.org/10.1037/0033-2909.117.1.21

Goffman, E. (2009). *Stigma: Notes on the management of spoiled identity*. Simon and Schuster.

Gonzalez-Liencres, C., Zapata, L. E., Iruretagoyena, G., Seinfeld, S., Perez-Mendez, L., Arroyo-Palacios, J., ... & Sanchez-Vives, M. V. (2020). Being the victim of intimate partner violence in virtual reality: first-versus third-person perspective. *Frontiers in Psychology*, *11*, 820. https://doi.org/10.3389/fpsyg.2020.00820

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464.

Greenwald, A. G., Poehlman, T. A., Uhlmann, E. L., & Banaji, M. R. (2009). Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity. *Journal of Personality and Social Psychology*, *97*(1), 17. https://doi.org/10.1037/a0015575

Groom, V., Bailenson, J. N., & Nass, C. (2009). The influence of racial embodiment on racial bias in immersive virtual environments. *Social Influence*, *4*(3), 231-248.

Guger, C., Edlinger, G., Leeb, R., Pfurtscheller, G., Angus, A., Garau, M., Brogni, A., Friedman, D., & Slater, M. (2004). Heart-Rate Variability and Event-Related ECG in Virtual Environments. In *Proceedings of the 7th Annual International Workshop Presence 2004* (pp. 240-245).

Guttentag, D. A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management*, *31*(5), 637-651.

Hall, E. T. (1963). A system for the notation of proxemic behavior. *American Anthropologist*, *65*(5), 1003-1026.

Hamilton-Giachritsis, C., Banakou, D., Quiroga, M. G., Giachritsis, C., & Slater, M. (2018). Reducing risk and improving maternal perspective-taking and empathy using virtual embodiment. *Scientific Reports*, *8*(1), 2975.

Hand, S., & Varan, D. (2008, July). Interactive narratives: Exploring the links between empathy, interactivity and structure. In *European Conference on Interactive Television*(pp. 11-19). Springer, Berlin, Heidelberg.

Harris, L. T., & Fiske, S. T. (2006). Dehumanizing the lowest of the low: Neuroimaging responses to extreme out-groups. *Psychological Science*, *17*(10), 847-853.

Hasler, B. S., Spanlang, B., & Slater, M. (2017). Virtual race transformation reverses racial in-group bias. *PloS one*, *12*(4), e0174965. https://doi.org/10.1371/journal.pone.0174965

Heeter, C. (1992). Being there: The subjective experience of presence. *Presence: Teleoperators & Virtual Environments*, *1*(2), 262-271.

Herrera, F., Bailenson, J., Weisz, E., Ogle, E., & Zaki, J. (2018). Building long-term empathy: A large-scale comparison of traditional and virtual reality perspective-taking. *PloS one*, *13*(10), e0204494. https://doi.org/10.1371/journal.pone.0204494

Hershfield, H. E., Goldstein, D. G., Sharpe, W. F., Fox, J., Yeykelis, L., Carstensen, L. L., & Bailenson, J. N. (2011). Increasing saving behavior through age-progressed renderings of the future self. *Journal of Marketing Research*, *48*(SPL), S23-S37. https://doi.org/10.1509/jmkr.48.SPL.S23

Hovland, C. I., Janis, I. L., & Kelley, H. H. (1953). Communication and persuasion.

HTC (2019). *VR for Impact*. Retrieved from https://vrforimpact.com/

Huang, Y. C., Backman, S. J., Chang, L. L., Backman, K. F., & McGuire, F. A. (2013). Experiencing student learning and tourism training in a 3D virtual world: An exploratory study. *Journal of Hospitality, Leisure, Sport & Tourism Education*, *13*, 190-201. https://doi.org/10.1016/j.jhlste.2013.09.007

Idson, L. C., & Mischel, W. (2001). The personality of familiar and significant people: The lay perceiver as a social–cognitive theorist. *Journal of Personality and Social Psychology*, *80*(4), 585. https://doi.org/10.1037/0022-3514.80.4.585

Jackson, P. L., Michon, P. E., Geslin, E., Carignan, M., & Beaudoin, D. (2015). EEVEE: The empathy-enhancing virtual evolving environment. *Frontiers in Human Neuroscience*, *9*, 112. https://doi.org/10.3389/fnhum.2015.00112

Kilteni, K., Bergstrom, I., & Slater, M. (2013). Drumming in immersive virtual reality: the body shapes the way we play. *IEEE Transactions on Visualization and Computer Graphics*, *19*(4), 597-605. https://doi.org/10.1109/TVCG.2013.29

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. *Presence: Teleoperators and Virtual Environments*, *21*(4), 373-387. https://doi.org/10.1162/PRES_a_00124

Kilteni, K., Maselli, A., Kording, K. P., & Slater, M. (2015). Over my fake body: body ownership illusions for studying the multisensory basis of own-body perception. *Frontiers in Human Neuroscience*, *9*. https://doi.org/10.3389/fnhum.2015.00141

Kim, K., Rosenthal, M. Z., Zielinski, D. J., & Brady, R. (2014). Effects of virtual environment platforms on emotional responses. *Computer Methods and Programs in Biomedicine*, *113*(3), 882-893. https://doi.org/10.1016/j.cmpb.2013.12.024

Kantontoka, S. (n.d.). 10 facts on mental health. Retrieved May 21, 2019, from https://www.who.int/features/factfiles/mental_health/mental_health_facts/en/index5.html

Kober, S. E., Kurzmann, J., & Neuper, C. (2012). Cortical correlate of spatial presence in 2D and 3D interactive virtual reality: an EEG study. *International Journal of Psychophysiology*, *83*(3), 365-374. https://doi.org/10.1016/j.ijpsycho.2011.12.003

Kosmas, P., Galanakis, G., Constantinou, V., Drossis, G., Christofi, M., Klironomos, I., ... & Stephanidis, C. (2020). Enhancing accessibility in cultural heritage environments: considerations for social computing. *Universal Access in the Information Society*, *19*(2), 471-482. https://doi.org/10.1007/s10209-019-00651-4

Kyrlitsias, C., Christofi, M., Michael-Grigoriou, D., Banakou, D., & Ioannou, A. (2020). A Virtual Tour of a Hardly Accessible Archaeological Site: the Effect of Immersive Virtual Reality in User Experience, Learning and Attitude Change. *Frontiers in Computer Science*, *2*, 23. https://doi.org/10.3389/fcomp.2020.00023

Kyrlitsias, C., Michael-Grigoriou, D., Banakou, D., & Christofi, M. (2020). Social Conformity in Immersive Virtual Environments: The Impact of Agents' Gaze Behavior. *Frontiers in Psychology*, *11*, 2254. https://doi.org/10.3389/fpsyg.2020.02254

Lamm, C., Batson, C. D., & Decety, J. (2007). The neural substrate of human empathy: effects of perspective-taking and cognitive appraisal. *Journal of Cognitive Neuroscience*, *19*(1), 42-58. https://doi.org/10.1162/jocn.2007.19.1.42

Jaron, L. (2010). You Are Not a Gadget: A Manifesto. *New York: Knopf*.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*.

Maister, L., Sebanz, N., Knoblich, G., & Tsakiris, M. (2013). Experiencing ownership over a dark-skinned body reduces implicit racial bias. *Cognition*, *128*(2), 170-178. https://doi.org/10.1016/j.cognition.2013.04.002

Makransky, G., Thisgaard, M. W., & Gadegaard, H. (2016). Virtual simulations as preparation for lab exercises: Assessing learning of key laboratory skills in microbiology and improvement of essential non-cognitive skills. *PloS one*, *11*(6), e0155895. https://doi.org/10.1371/journal.pone.0155895

Malińska, M., Zużewicz, K., Bugajska, J., & Grabowski, A. (2015). Heart rate variability (HRV) during virtual reality immersion. *International Journal of Occupational Safety and Ergonomics*, *21*(1), 47-54. https://doi.org/10.1080/10803548.2015.1017964

Malle, B. F. (2006). The actor-observer asymmetry in attribution: A (surprising) meta-analysis. *Psychological Bulletin*, *132*(6), 895. https://doi.org/10.1037/0033-2909.132.6.895

Marín-Morales, J., Llinares, C., Guixeres, J., & Alcañiz, M. (2020). Emotion recognition in immersive virtual reality: From statistics to affective computing. *Sensors*, *20*(18), 5163. https://doi.org/10.3390/s20185163

McAllister, G., & Irvine, J. J. (2002). The role of empathy in teaching culturally diverse students: A qualitative study of teachers' beliefs. *Journal of teacher education*, *53*(5), 433-443. https://doi.org/10.1177/002248702237397

McLeod, S. A. (2018, October 24). *Attitude measurement*. Simply Psychology. Retrieved from https://www.simplypsychology.org/attitude-measurement.html

Menezes, M. L. R., Samara, A., Galway, L., Sant'Anna, A., Verikas, A., Alonso-Fernandez, F., ... & Bond, R. (2017). Towards emotion recognition for virtual environments: an evaluation of eeg features on benchmark dataset. *Personal and Ubiquitous Computing*, 21(6), 1003-1013. https://doi.org/10.1007/s00779-017-1072-7

Michael , D., & Slater, M. (2012). Embodiment in a Strong Virtual Body Influences Weight Lifting Endurance. *8th FENS Forum of Neuroscience 2012.* Barcelona, Spain.

Michael-Grigoriou, D., Yiannakou, P., & Christofi, M. (2017, October). Intuitive interaction for exploring human anatomy in a VR setup. In *2017 23rd International Conference on Virtual Systems & Multimedia (VSMM)* (pp. 1-4). IEEE. https://doi.org/10.1109/VSMM.2017.8346287

Milk, C. (2015, March). How virtual reality can create the ultimate empathy machine. *TED*. Retrieved from https://www.ted.com/talks/chris_milk_how_virtual_reality_can_create_the_ultimate_empathy_machine

Minsky, M. (1980). Telepresence. *Omni.* 45–52.

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance improvement*, *42*(5), 34-37.

Moreno, R., & Mayer, R. E. (2002). Learning science in virtual reality multimedia environments: Role of methods and media. *Journal of educational psychology*, *94*(3), 598.

Myers, D.G. (2010). *Psychology* (9th ed.). New York: Worth.

Najm, A., Michael-Grigoriou, D., Kyrlitsias, C., Christofi, M., Hadjipanayi, C. & Sokratous, D (2020). A Virtual Reality Adaptive Exergame for the Enhancement of Physical Rehabilitation Using Social Facilitation. In *ICAT-EGVE 2020-International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments-Posters and Demos* (Vol. 36, pp. 163-170). The Eurographics Association. https://doi.org/10.2312/egve.20201269

National Institute on Drug Abuse. (2018). What are marijuana effects? *NIDA*. Retrieved from https://www.drugabuse.gov/publications/research-reports/marijuana/what-are-marijuana-effects

Noë, A. (2004). *Action in perception*. MIT press.

Nosek, B. A., Smyth, F. L., Hansen, J. J., Devos, T., Lindner, N. M., Ranganath, K. A., ... & Banaji, M. R. (2007). Pervasiveness and correlates of implicit attitudes and

stereotypes. *European Review of Social Psychology*, *18*(1), 36-88. https://doi.org/10.1080/10463280701489053

Norrby, M., Grebner, C., Eriksson, J., & Bostrom, J. (2015). Molecular rift: virtual reality for drug designers. *Journal of Chemical Information and Modeling*, *55*(11), 2475-2484. https://doi.org/10.1021/acs.jcim.5b00544

O'Keefe, D. J. (2015). *Persuasion: Theory and research*. Sage Publications.

Opriş, D., Pintea, S., García-Palacios, A., Botella, C., Szamosközi, Ş., & David, D. (2012). Virtual reality exposure therapy in anxiety disorders: a quantitative meta-analysis. *Depression and Anxiety*, *29*(2), 85-93. https://doi.org/10.1002/da.20910

O'Regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences*, *24*(5), 939-973. https://doi.org/10.1017/S0140525X01000115

Ostrom, T. M. (1969). The relationship between the affective, behavioral, and cognitive components of attitude. *Journal of Experimental Social Psychology*, *5*(1), 12-30.

Pappa G., Ioannou N., Christofi M., Lanitis A. (2018) Preparing Student Mobility Through a VR Application for Cultural Education. In: Ioannides M., Martins J., Žarnić R., Lim V. (eds) Advances in Digital Cultural Heritage. Lecture Notes in Computer Science, vol 10754. Springer, Cham. https://doi.org/10.1007/978-3-319-75789-6_16

Parsons, T. D., Bowerly, T., Buckwalter, J. G., & Rizzo, A. A. (2007). A controlled clinical comparison of attention performance in children with ADHD in a virtual reality classroom compared to standard neuropsychological methods. *Child Neuropsychology*, *13*(4), 363-381. https://doi.org/10.1080/13825580600943473

Passig, D., Tzuriel, D., & Eshel-Kedmi, G. (2016). Improving children's cognitive modifiability by dynamic assessment in 3D Immersive Virtual Reality environments. *Computers & Education*, *95*, 296-308. https://doi.org/10.1016/j.compedu.2016.01.009

Peck, T. C., Seinfeld, S., Aglioti, S. M., & Slater, M. (2013). Putting yourself in the skin of a black avatar reduces implicit racial bias. *Consciousness and Cognition*, *22*(3), 779-787. https://doi.org/10.1016/j.concog.2013.04.016

Penn, D. L., Ivory, J. D., & Judge, A. (2010). The virtual doppelganger: Effects of a virtual reality simulator on perceptions of schizophrenia. *The Journal of Nervous and Mental Disease*, *198*(6), 437-443. https://doi.org/10.1097/NMD.0b013e3181e07d66

Perdue, C. W., & Gurtman, M. B. (1990). Evidence for the automaticity of ageism. *Journal of Experimental Social Psychology*, *26*(3), 199-216.

Richards, D., & Taylor, M. (2015). A Comparison of learning gains when using a 2D simulation tool versus a 3D virtual world: An experiment to find the right representation involving the Marginal Value Theorem. *Computers & Education*, *86*, 157-171. https://doi.org/10.1016/j.compedu.2015.03.009

Rodríguez, A., Rey, B., Clemente, M., Wrzesien, M., & Alcañiz, M. (2015). Assessing brain activations associated with emotional regulation during virtual reality mood induction procedures. *Expert Systems with Applications*, *42*(3), 1699-1709. https://doi.org/10.1016/j.eswa.2014.10.006

Roel Lesur, M., Lyn, S., & Lenggenhager, B. (2020). How Does Embodying a Transgender Narrative Influence Social Bias? An Explorative Study in an Artistic Context. *Frontiers in Psychology*, *11*, 1861. https://doi.org/10.3389/fpsyg.2020.01861

Rosenberg, M. J. (1956). Cognitive structure and attitudinal affect. *The Journal of Abnormal and Social Psychology*, *53*(3), 367.

Ross, L. (1977). The intuitive psychologist and his shortcomings: Distortions in the attribution process. In *Advances in Experimental Social psychology* (Vol. 10, pp. 173-220). Academic Press.

Roswell, R. O., Cogburn, C. D., Tocco, J., Martinez, J., Bangeranye, C., Bailenson, J. N., ... & Smith, L. (2020). Cultivating empathy through virtual reality: Advancing conversations about racism, inequity, and climate in medicine. *Academic Medicine*, *95*(12), 1882-1886. https://doi.org/10.1097/ACM.0000000000003615

Roussou, M. (2002). Virtual heritage: from the research lab to the broad public. *Bar International Series*, *1075*, 93-100.

Roy, M. J., Costanzo, M. E., Jovanovic, T., Leaman, S., Taylor, P., Norrholm, S. D., & Rizzo, A. A. (2013). Heart rate response to fear conditioning and virtual reality in subthreshold PTSD. *Annual Review of Cybertherapy and Telemedicine*, *191*, 115-119. https://doi.org/10.3233/978-1-61499-282-0-115

Psotka, J. (1995). Immersive training systems: Virtual reality and education and training. *Instructional Science*, *23*(5-6), 405-431.

Rua, H., & Alvito, P. (2011). Living the past: 3D models, virtual reality and game engines as tools for supporting archaeology and the reconstruction of cultural heritage–the case-study of the Roman villa of Casal de Freiria. *Journal of Archaeological Science*, *38*(12), 3296-3308. https://doi.org/10.1016/j.jas.2011.07.015

Salzman, M. C., Dede, C., Loftin, R. B., & Chen, J. (1999). A model for understanding how virtual reality aids complex conceptual learning. *Presence: Teleoperators & Virtual Environments*, *8*(3), 293-316. https://doi.org/10.1162/105474699566242

Sanchez-Vives, M. V., & Slater, M. (2005). From presence to consciousness through virtual reality. *Nature Reviews Neuroscience*, *6*(4), 332. https://doi.org/10.1038/nrn1651

Schutte, N. S., & Stilinović, E. J. (2017). Facilitating empathy through virtual reality. *Motivation and Emotion*, *41*(6), 708-712. https://doi.org/10.1007/s11031-017-9641-7

Seidel, R. J., & Chatelier, P. R. (Eds.). (2013). *Virtual reality, training's future?: perspectives on virtual reality and related emerging technologies* (Vol. 6). Springer Science & Business Media.

Seinfeld, S., Arroyo-Palacios, J., Iruretagoyena, G., Hortensius, R., Zapata, L. E., Borland, D., ... & Sanchez-Vives, M. V. (2018). Offenders become the victim in virtual reality: impact of changing perspective in domestic violence. *Scientific Reports*, *8*(1), 2692. https://doi.org/10.1038/s41598-018-19987-7

Seo, S. H., & Lee, J. T. (2010). Stress and EEG. In *Convergence and Hybrid Information Technologies*. IntechOpen.

Sidanius, J., & Pratto, F. (2001). *Social dominance: An intergroup theory of social hierarchy and oppression*. Cambridge University Press. https://doi.org/10.1017/CBO9781139175043

Simonson, M. R. (1977). Attitude change and achievement: Dissonance theory in education. *The Journal of Educational Research, 70*(3), 163-169.

Simonson, M. R., & Maushak, N. (1996). Instructional technology and attitude change. *Faculty Books and Book Chapters*. 12.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1535), 3549-3557. https://doi.org/10.1098/rstb.2009.0138

Slater, M., & Sanchez-Vives, M. V. (2014). Transcending the self in immersive virtual reality. *Computer*, *47*(7), 24-30. https://doi.org/10.1109/MC.2014.198

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. *Frontiers in Robotics and AI*, *3*, 74. https://doi.org/10.3389/frobt.2016.00074

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators & Virtual Environments*, *6*(6), 603-616.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*(7), 749-752.

Shechtman, Z., & Tanus, H. (2006). Counseling groups for Arab adolescents in an intergroup conflict in Israel: Report of an outcome study. *Peace and Conflict*, *12*(2), 119-137. https://doi.org/10.1207/s15327949pac1202_2

Sidanius, J., & Pratto, F. (2001). *Social dominance: An intergroup theory of social hierarchy and oppression*. Cambridge University Press.

Spence, A., & Townsend, E. (2007). Predicting behaviour towards genetically modified food using implicit and explicit attitudes. *British Journal of Social Psychology*, *46*(2), 437-457. https://doi.org/10.1348/014466606X152261

Spreng*, R. N., McKinnon*, M. C., Mar, R. A., & Levine, B. (2009). The Toronto Empathy Questionnaire: Scale development and initial validation of a factor-analytic solution to multiple empathy measures. *Journal of Personality Assessment*, *91*(1), 62-71. https://doi.org/10.1080/00223890802484381

Stavroulia, K.E., Baka, E., Christofi, M., Michael-Grigoriou, D., Magnenat-Thalmann, N. & Lanitis, A. (2018). A virtual reality environment simulating drug use in schools: effect on emotions and mood states. *International Conference on Information, Communication Technologies in Education, ICICTE 2018*, Chania, Greece, 5 and 7 July, 2018.

Stavroulia, K. E., Christofi, M., Baka, E., Michael-Grigoriou, D., Magnenat-Thalmann, N., & Lanitis, A. (2019). Assessing the emotional impact of virtual reality-based teacher training. *The International Journal of Information and Learning Technology*, *36*(3), 192-217. https://doi.org/10.1108/IJILT-11-2018-0127

Stavroulia KE., Christofi M., Zarraonandia T., Michael-Grigoriou D., Lanitis A. (2019) Virtual Reality Environments (VREs) for Training and Learning. In: Díaz P., Ioannou A., Bhagat K., Spector J. (eds) Learning in a Digital World. Smart Computing and Intelligence. Springer, Singapore. https://doi.org/10.1007/978-981-13-8265-9_10

Steed, A., Pan, Y., Watson, Z., & Slater, M. (2018). 'We Wait'-The Impact of Character Responsiveness and Self Embodiment on Presence and Interest in an Immersive News Experience. *Frontiers in Robotics and AI*, *5*, 112. https://doi.org/10.3389/frobt.2018.00112

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295-312.

Szily, E., & Kéri, S. (2008). Emotion-related brain regions. *Ideggyógyászati szemle*, *61*(3-4), 77-86.

Tajfel, H. (1974). Social identity and intergroup behaviour. *Information (International Social Science Council)*, *13*(2), 65-93.

Tajfel, H., Turner, J. C., Austin, W. G., & Worchel, S. (1979). An integrative theory of intergroup conflict. *Organizational Identity: A Reader*, 56-65.

Tanner, K. (2018). Experimental research. In Research Methods (pp. 337–356). *Elsevier*. https://doi.org/10.1016/b978-0-08-102220-7.00014-5

The Bloodshot Look: Why Cannabis Causes Red Eyes. (2016, October 18). *MedWell Health and Wellness Centers*. Retrieved from http://www.medwellhealth.net/the-bloodshot-look-why-cannabis-causes-red-eyes/

The Recovery Village. (2019, November 14). The Difference Between Crack And Cocaine. Retrieved January 07, 2021, from https://www.palmerlakerecovery.com/blog/difference-crack-cocaine/

Thisgaard, M., & Makransky, G. (2017). Virtual learning simulations in high school: Effects on cognitive and non-cognitive outcomes and implications on the development of STEM academic and career choice. *Frontiers in Psychology*, *8*, 805. https://doi.org/10.3389/fpsyg.2017.00805

Thomas, S. (2020, November 17). Cocaine Abuse Signs - Get Rehab Treatment in our Rehabilitation Centers. Retrieved January 07, 2021, from https://americanaddictioncenters.org/cocaine-treatment/signs

Thomas, G., Kloner, R. A., & Rezkalla, S. (2014). Adverse cardiovascular, cerebrovascular, and peripheral vascular effects of marijuana inhalation: what cardiologists need to know. *The American Journal of Cardiology*, *113*(1), 187-190. https://doi.org/10.1016/j.amjcard.2013.09.042

Thurstone, L. L. (1928). Attitudes can be measured. *American Journal of Sociology*, *33*(4), 529-554.

Tomasello, M. (2009). *The cultural origins of human cognition*. Harvard University Press.

Tost, L. P., & Economou, M. (2009). Worth a thousand words? The usefulness of immersive virtual reality for learning in cultural heritage settings. *International Journal of Architectural Computing*, *7*(1), 157-176. https://doi.org/10.1260/147807709788549367

Tsakiris, M., Prabhu, G., & Haggard, P. (2006). Having a body versus moving your body: How agency structures body-ownership. *Consciousness and Cognition*, *15*(2), 423–432. https://doi.org/10.1016/j.concog.2005.09.004

Turkle, S. (1995). Life on the screen: identity in the age of the Internet Simon & Schuster. *New York*.

Turkle, S. (1999). Cyberspace and identity. *Contemporary Sociology*, *28*(6), 643-648.

Tussyadiah, I. P., Wang, D., & Jia, C. H. (2017). Virtual reality and attitudes toward tourism destinations. In *Information and Communication Technologies in Tourism 2017* (pp. 229-239). Springer, Cham. https://doi.org/10.1007/978-3-319-51168-9_17

Tussyadiah, I. P., Wang, D., Jung, T. H., & tom Dieck, M. C. (2018). Virtual reality, presence, and attitude change: Empirical evidence from tourism. *Tourism Management*, *66*, 140-154. https://doi.org/10.1016/j.tourman.2017.12.003

UNVR. (2019). *UN Virtual Reality*. Retrieved from https://unitednationsvirtualreality.wordpress.com/virtual-reality/

Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using presence questionnaires in reality. *Presence: Teleoperators & Virtual Environments*, *9*(5), 497-503.

Van der Heijden, H. (2004). User acceptance of hedonic information systems. *MIS quarterly*, 695-704.

van Loon, A., Bailenson, J., Zaki, J., Bostick, J., & Willer, R. (2018). Virtual reality perspective-taking increases cognitive empathy for specific others. *PloS one*, *13*(8), e0202442. https://doi.org/10.1371/journal.pone.0202442

Vaughan, G. M., & Hogg, M. A. (2005). Introduction to Social Psychology. Frenchs Forest. *New South Wales, NSW: Pearson Education*.

Ventura, S., Badenes-Ribera, L., Herrero, R., Cebolla, A., Galiana, L., & Baños, R. (2020). Virtual reality as a medium to elicit empathy: a meta-analysis. *Cyberpsychology, Behavior, and Social Networking*, *23*(10), 667-676. https://doi.org/10.1089/cyber.2019.0681

Vorderer, P., Knobloch, S., & Schramm, H. (2001). Does entertainment suffer from interactivity? The impact of watching an interactive TV movie on viewers' experience of entertainment. *Media Psychology*, *3*(4), 343-363. https://doi.org/10.1207/S1532785XMEP0304_03

Watson, D., & Clark, L. A. (1994). The Panas-X. *Manual for the positive and negative affect schedule-expanded form. The University of Iowa*.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070.

Webster, R. (2016). Declarative knowledge acquisition in immersive virtual learning environments. *Interactive Learning Environments*, *24*(6), 1319-1333. https://doi.org/10.1080/10494820.2014.994533

Wilson, C. J., & Soranzo, A. (2015). The use of virtual reality in psychology: A case study in visual perception. *Computational and Mathematical Methods in Medicine*, *2015*. https://doi.org/10.1155/2015/151702

Wolf, M. J., & Perron, B. (2013). Immersion, Engagement, and Presence: A Method for Analyzing 3-D Video Games Alison McMahan. *The Video Game Theory Reader. Routledge*, 89-108.

Yee, N., & Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human Communication Research*, *33*(3), 271-290. https://doi.org/10.1111/j.1468-2958.2007.00299.x

Yee, N., Bailenson, J. N., & Ducheneaut, N. (2009). The Proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Communication Research*, *36*(2), 285-312. https://doi.org/10.1177/0093650208330254

Yu, P. L., Shen, C., & Smith, G. S. (Eds.). (2018). *Relevance and Application of Heritage in Contemporary Society*. Routledge.

Zaki, J., & Ochsner, K. N. (2012). The neuroscience of empathy: progress, pitfalls and promise. *Nature Neuroscience*, *15*(5), 675.

Zick, A., Küpper, B., & Hövermann, A. (2011). *Intolerance, Prejudice and Discrimination: A European Report.*

APPENDIX A-1

The scenario and dialogues of the application of Study 1.

Scene: School outdoor space

It is break time.

1) <u>Student-healthy perspective:</u>

A girl (St_1) is watching her classmate having done drug use.

She is asking her other classmate (St_2) what has happened.

Her classmate is trying to pressure her take a cigarette.

The girl sees the teacher coming (T).

She is afraid and leave.

Dialogues:

0. St_1: Kosta what has happened to Nikos?
1. St_2: hahahaha (The student is laughing)
2. St_1: Come on Kosta…is Nikos feeling sick or something?
3. Should we inform the teacher?
4. Niko are you ok?
5. St_2: Don't be stupid Anna! Nikos is perfect…
6. St_1: Does Nikos seem perfect to you Kosta?
7. Niko can I help you? Do you want me to call the teacher?
8. St_2: Nikos just smoked some cigarettes…that is all…
9. St_1: What kind of cigarettes Kosta?
10. It smells weird here, not like regular cigarettes.
11. Niko what did he gave you?
12. St_2: The best there are!
13. Relax, its just a doobie !
14. Do you want one?
15. You will feel better and happier!
16. All your problems will disappear…
17. St_1: You brought cannabis cigarettes to school?!

18. St_2: Hahaha
19. St_1: How dare you give Nikos marijuana joints?
20. St_2: Hahaha you want one?
21. St_1: I do not want your drugs Kosta!
22. I will tell the teacher…
23. St_2: Don't even think about it stupid girl…
24. I'll tell the teacher that you gave one to Nikos and put evidence in your bag…
25. Don't mess with me little Anna…
26. St_1: The teacher will not believe you Kosta…
27. St_2: The teacher will believe the marijuana in your bag Anna…
28. If you say a word to anyone something bad will happen to your little sister…
29. St_1: Are you threatening me Kosta?
30. St_2: Of course not Anna…
31. I am sure this secret will stay between us…
32. St_1: The teacher is coming…
33. **T**: What has happened here?
34. St_2: We don't know professor…
35. Nikos told me he is not feeling well…
36. **T:** Niko what exactly do you feel?
37. **T:** Niko do you hear me?
38. Kosta, Anna did he say anything to you?
39. Was he feeling dizzy?
40. Did he fall or hit?
41. St_1: I…I…I do not know professor… I do not know…
42. Please I need to go to my classroom…
43. **T:** Kosta what has happened?
44. St_2: I do not know professor, Anna was already here when I came…
45. and Nikos did not say anything…
46. **T:** Niko do you hear me?
47. Niko...Niko...

Nikos fades

2) <u>Student-drug user perspective:</u>

The student is sitting at a bench unable to move.

Everything around him is blur.

He cannot see well.

He cannot hear well.

He can barely see the teacher coming.

He can barely hear the dialogue of the 2 students regarding drug use.

He is unable to answer to the teacher about how he feels.

He faints.

- The dialogue will be exactly the same but the user will not be able to clearly see the text in the bubbles so that the user cannot read.

3) <u>Teacher perspective:</u>

A teacher is walking to the yard to make sure everything runs smoothly during the break.

The teacher notices something strange happening.

In a odd point back in the yard there are 3 students.

One of the students has made drug use.

The other 2 students are watching him.

One of those two students is being bullied/pressured to also take a pill.

The teacher approaches.

The bully says to the teacher that something happened to his classmate.

The bullied girl is frightened and leaves.

The teacher tries to interact with the student under drug use to ask for what happened.

APPENDIX A-2

EEG detailed results from Study 1

For further validation of our results, we recorded brain signals from several brain areas using a wireless EMOTIV EEG device. We recorded separately the three aforementioned perspectives (teacher, user and healthy) and we were focused mainly on the frontal and parietal areas of the brain. It has been proved that parietal area plays an important role in the experience of presence (Kober, Kurzmann & Neuper, 2012; Baka, Stavroulia, Magnenat-Thalmann, & Lanitis, 2018) and can be used as a measure for the validation of its existence. Frontal lobe is associated with cognitive tasks, decision making and attention (Szily & Kéri, 2008). Moreover, we calculated the general dominant frequency of the brain for the three perspectives. For the analysis of the data, EEGlab was used, a MATLAB toolbox.

Table below presents the results for each brain area based on each perspective. We can clearly see that when the participant had the experience of a student (user or healthy), there is a difference mainly for the parietal area and the general frequency. This difference concerns different brain states, such as beta state, which ranges from 12.5 to 35 Hz and alpha state from 8 to Hz.

Results for each brain area based on the perspective.

	Frontal (Hz)		**Parietal (Hz)**		**Dominant Frequency (Hz)**	
	Mean Value	**Std. Deviation**	**Mean Value**	**Std. Deviation**	**Mean Value**	**Std. Deviation**
Teacher	12.8	3.8	14.1	4.6	15.4	5.4
User	12	4.4	11.7	3.5	12.6	3.1
Healthy	13.5	3.8	3.7	3.7	12.7	3.3

In order to validate the sense of presence we need the existence of alpha state in the parietal area, which is apparent only in the student perspective. Based on a Mann-

Whitney U test we found that there is a significant difference between these perspectives for the parietal area (p=0.013<0.05) and for the dominant frequency (p=0.012<0.05) (see Figure 8 and Figure 9).

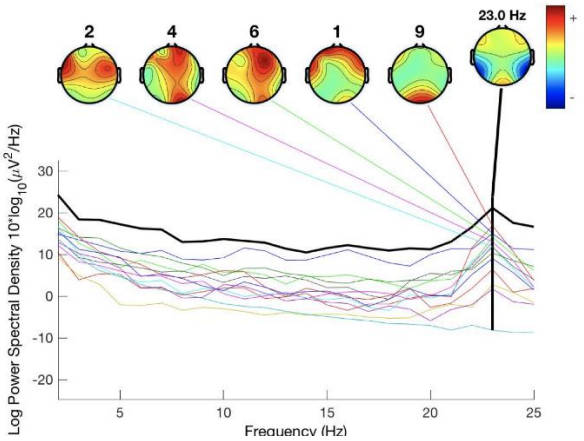


Figure 46: Dominant Frequency for Teacher Perspective. The diagram was constructed after Independent Component Analysis (ICA).

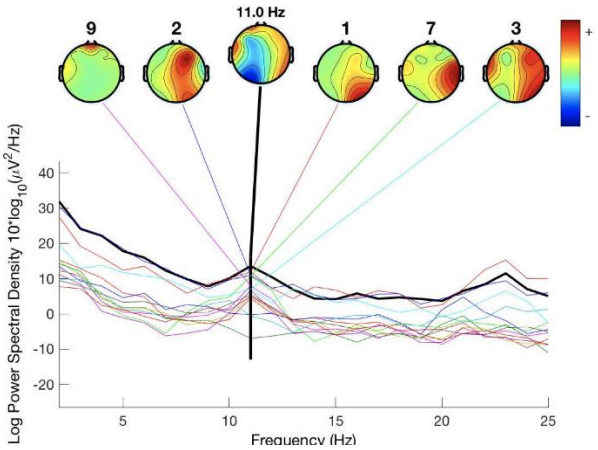


Figure 47: Dominant Frequency for the healthy student perspective. The diagram was constructed after Independent Component Analysis (ICA).

We run a Kruskal-Wallis test to compare all the three perspectives. Given that we found a statistically significant difference for the parietal (p=0.042) and for the dominant frequency (p=0.039), we used a Mann-Whitney test to compare them in two groups. So, we noticed that there is a significant difference for the teacher-user group with p =0.043

for the parietal area and p=0.047 for the dominant frequency as well as for the teacher - healthy group with p=0.049 for the parietal area and p=0.040 for the general frequency.

Frontal area never presented a significant difference between any group or perspective. As we can see in the table, we found alpha or low beta for all the perspectives which means that in all cases participants faced a cognitive task in which they were concentrated.

On the other hand, the sense of presence was noticed only in the student (healthy and user) perspective, which means that during the teacher one, participants maybe did not find so much interest or they did not feel they actually were in the position of the teacher. On the contrary, during the student perspective, participants felt more involved in the process and this is also presented in the dominant frequency, which represents the alpha state. In Figure 10 we can see an example of a channel in the parietal area, indicating this alpha state.

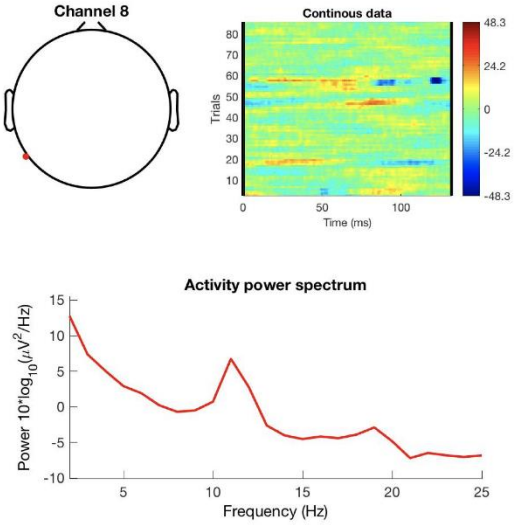


Figure 48: Example of a channel in the parietal area for the student user perspective. We can notice the peak of the frequency at around 11 Hz, which is a clear alpha state.

APPENDIX B-1

Narrative

#1 bathroom

You are a man named Mark, a 28-year-old accountant. You are living with your girlfriend Amanda. You have recently lost your mother due to cancer and work is getting busier by the day, which is stressing you out.

It's Sunday night, and Amanda has invited your friends Lisa, Greg and Nick to come over for dinner at your place to take your mind off things. You are at the bathroom getting ready and your girlfriend comes in and tells you:

- **Amanda:** *"Oh here you are! Look yourself at the mirror! Your mother would be so proud of you. I know you are having a hard time after losing her due to cancer, but i have invited our friends for dinner, maybe it will take your mind off of it, and work. Wanna help me set up the dinner table? When you are ready, come. Don't take too long!"*

#2 dinner

You finish getting ready and head to the living room. The dinner table is half way set up. You help Amanda getting the food and the table ready. Your friends come over half an hour later. You sit at the head of the table. Freshly made sushi and wine is on the table and the conversation turned to sports as per usual.

- **Nick:** *"Mark, did you see the match last night? Wish I hadn't seen it!"*
- **Greg:** *"Hey I've been telling you both to change teams since forever! Now you can both sit in the corner and think about your life choices!"*
- **Lisa:** *"Oh God, what is with boys and sports honestly? Can we talk about something else? How is work Mark? You've been quiet tonight"*
- **Amanda:** *"Isn't Mark always quiet? I think it's best if we stick to sports for once. Work is stressing him out lately. Amongst other stuff."*

The work conversation made you sweaty and nervous and you had to end the dinner soon. Indeed, work has made you quieter and more nervous than usual and you ended up falling asleep a few hours later.

#3 work

Work the next day was proven to be one of the same. You are sitting at your desk, office noises like keyboards and staplers surrounded you. Two other coworkers in the same office at you, one on your right and the other in front of you at the other side of the room. A few minutes later, your boss comes in and says to you:

- **Boss:** *"Mark I need the files I sent you yesterday checked and at my office by lunch time. Don't be late I got the clients waiting!"*

Your coworker on your right notices his attitude, turns to you and says:

- **Coworker:** *"Oof, he's in a mood again! You okay Mark? You look so tense mate! Maybe you come with me at John's party Friday night to release all that stress? Heard he's gonna bring even a DJ! "*

 # 4 party 1

This idea sounds not bad to you, and you decide to go. Amanda stays home and calls Lisa to have a girl night and you meet with your coworker at John's party. His living room is heavily packed with people! Loud music, different colored lighting, people dancing, drinking all kinds of soda, wine and beer. Your coworker approaches you and says:

- **Coworker:** *"MARK MY MATE ! What did I tell you? Look at this party! Time to forget about our work and loosen up boy! Drink, dance, have some fun!"*

You both approach a guy with quite the muscles, standing in front of a small table with some kind of white powder lined up in stripes, looking more hyped and energetic for a party mood. He sees you and says (almost shouts):

- **Guy at party:** *"YO ! You look tense ! Chill out bro ! Why so serious? You came here to have fun right? I've got just the thing for you! Come with me !*

 # 5 party 2

You hesitate at first, but you really needed an escape from your stress and your mother's death, so you follow him to the toilet. You notice he carried with him a little bag with white powder with him, a small spoon and a razor blade. He closes the door and places some powder on the bathroom table using the spoon and lines it up using the razor blade. Ignorant as you are, just smoked a couple of cigarettes during your high school years, it took you awhile to realize that he was giving you cocaine. He finished lining it and he looks at you, and you look at him back and you say:

- **You:** *"I think there has been a small misunderstanding here. I am not like that, I don't want to take that."*
- **Guy at party:** *"Dude ! Why you so lame ?! How do you expect to have some fun? Do I have to teach you everything? It's harmless fun! You will feel a different, well, more fun version of you, in no time! Trust me dude! Just snort the damn powder!"*

You end up inhaling the powder and next thing you remember, is you at the dance floor, dancing furiously at the beat and your heart pounding fast, alternating between a few more lines of cocaine powder and wine. Your coworker ended up driving you home from this truly chaotic night you just had.

You woke up in the morning, feeling more energetic than ever, you skipped your usual breakfast, had a sip of coffee and headed straight to work. This night never left your mind, you ended up finding out who the dealer was at the party and made regular visits to him, just to feel a bit more alive again.

 # 6 dealer

You go to your dealer for your weekly dose, and he says:

- **Dealer:** *"You again… I still wonder how you can afford all this man! But not my problem… Here you go… Knock yourself out. But demand is getting bigger and so are the prices. You better bring more money next time champ or else don't bother showing up."*

This troubled you… Amanda had lost her job too, cause of the economic crisis. you were barely making enough money to pay your rent and bills, but cocaine, was the only way out of your problems, you couldn't resist.

 # 7 work 2

A few days later… You are again at work, more hyper than ever from doing use a few min ago in your car, hidden from plain sight, barely paying attention to anything. Your boss comes in and yells at you:

- **Boss:** *"Mark ! MARK ! I am talking to you! I asked you to head over to the company yesterday and close the deal with them and you never showed up ! What the fuck is wrong with you ?"*

He leaves, and your coworker looks at you and says"

- **Coworker:** *"Have you looked yourself at a mirror lately mate? I am worried about you! Also look what just happened !"*

 # 8 bathroom 2

Later at night, you are locked in the bathroom, taking one more snort. Amanda knocks on the door and says:

- **Amanda:** *"Baby, what are you doing in there? Why did you lock the door? Food will get cold"*
- **Mark:** *"I said I'm not hungry! I will be there in a moment! Just got out the shower ! "*

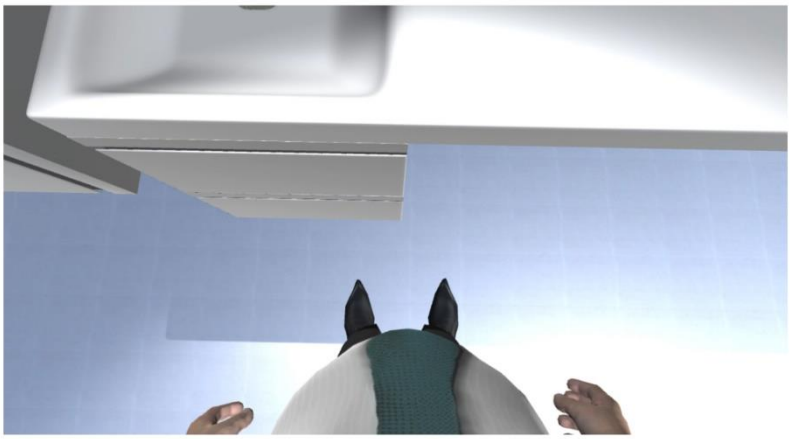
 # 9 final scene

Minutes later you go to the living room where you see Amanda close to your work suitcase.

- **Amanda: "***Mark i need to speak with you. I saw the bank statement. It showed a big withdrawal of money a few weeks ago. I found these in your bag the other day. This explains a lot ! The weight loss, the mood swings, the blood on your pillow from your nose. You need to stop this now ! I don't want to lose you from drugs. Please mark, seek some help! What would your mother think if she saw you like that? Help yourself, or I am leaving you"*

APPENDIX B-2

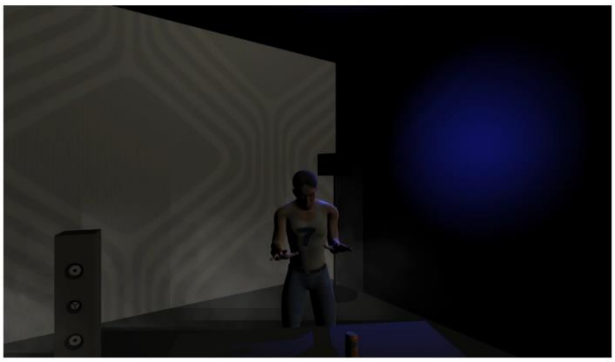
Additional views from Scene 1



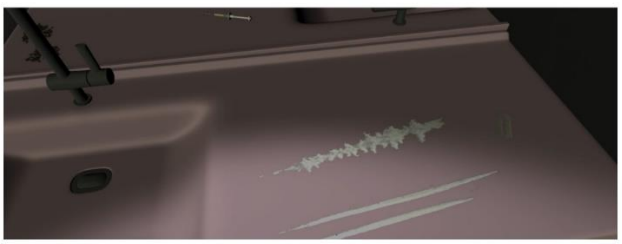
Additional views from Scene 2

Additional views from Scene 3

Additional views from Scene 4



Additional views from Scene 5



Additional view from Scene 6

Additional view from Scene 7

Additional views from Scene 8

Additional views from Scene 9

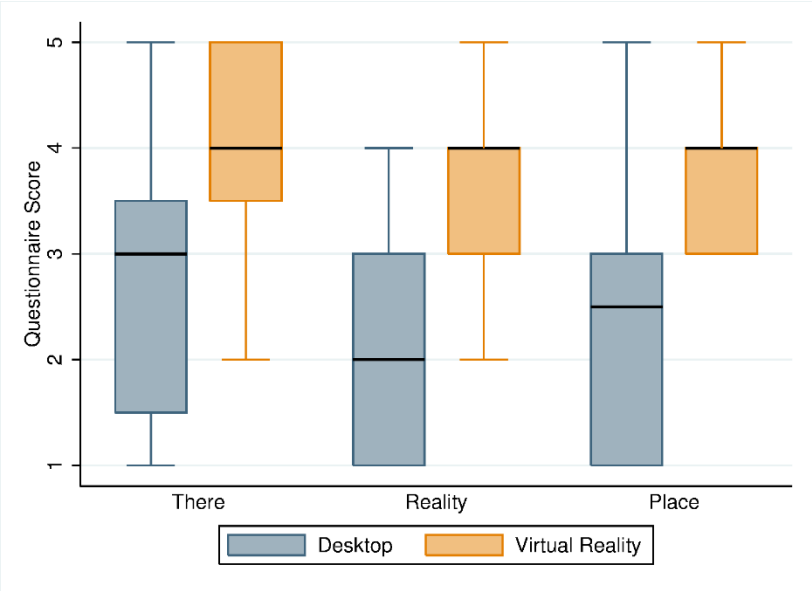
APPENDIX C-1

The knowledge test questions

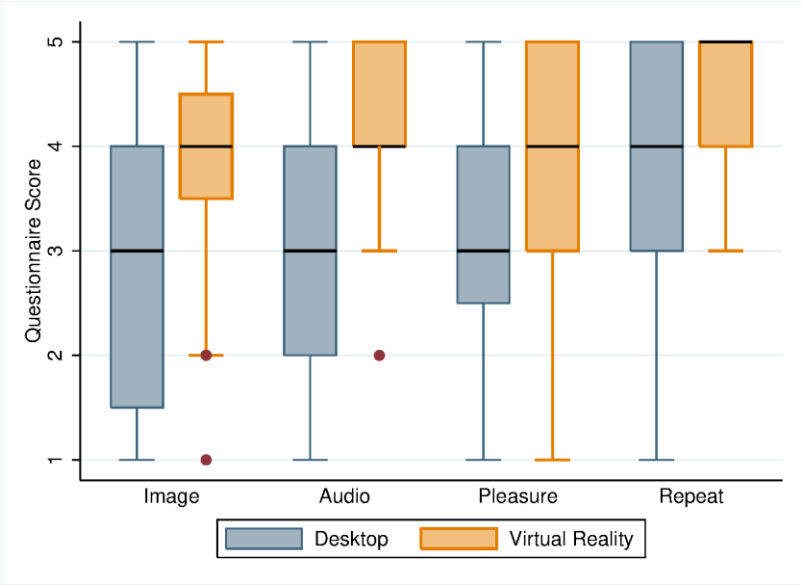
1.	In what province of Cyprus is the settlement of Choirokitia located?
2.	What do the buildings of Choirokitia look like?
3.	What was in the center of the dwellings?
4.	The buildings of Choirokitia were built in such a way as to protect the inhabitants from:
5.	What was one of the materials used by residents to build tools?
6.	In what time period does the settlement of Choirokitia date to?
7.	Which of the following animals was reared by the inhabitants of Chirokitia?
8.	What color is the picrolite that was abundant in the river Kouri?
9.	What is the dominant theme of the figurines found in the settlement of Choirokitia?
10.	The average life of the inhabitants of Choirokitia varied between:

APPENDIX C-2

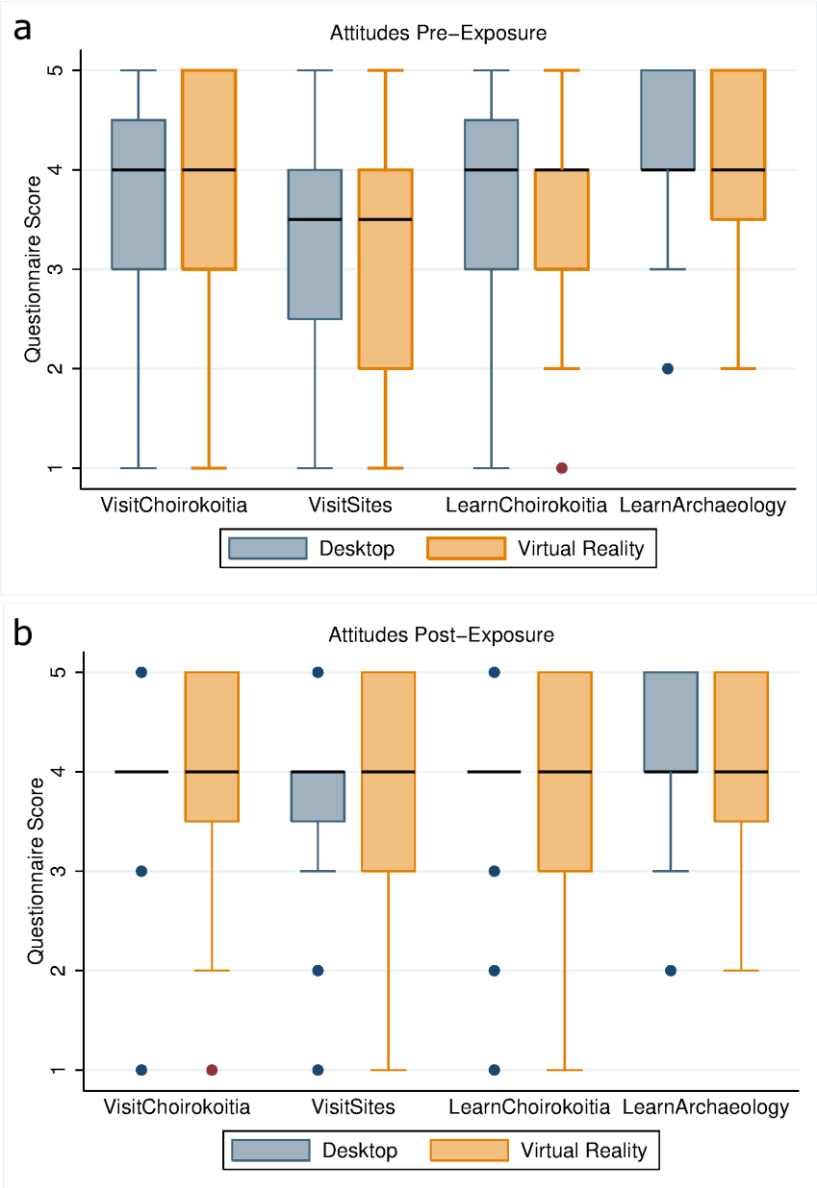
Box plots of questionnaire responses on Presence. The thick horizontal lines are the medians, and the boxes the interquartile ranges (IQR). The whiskers stretch to the data points that are within the median ± 1.5 IQR.



Box plots of questionnaire responses on User Experience. The thick horizontal lines are the medians, and the boxes the interquartile ranges (IQR). The whiskers stretch to the data points that are within the median ± 1.5 IQR, with outliers beyond this shown as single points.



Box plots of questionnaire responses on Attitudes (a) pre-exposure and (b) post-exposure.



APPENDIX C-3

Pearson correlations among variables in Desktop condition

	1	2	3	4	5	6	7	8
1. Presence	–							
2. UserExperience	.830**	–						
3. preAttitudes	.303	.206	–					
4. postAttitudes	.439	.297	.766**	–				
5. dAttitudes	.151	.102	-.446*	.234	–			
6. preScore	.610**	.606**	.139	.082	-.097	–		
7. postScore	.237	.128	.387	.393	-.037	.284	–	
8. dScore	-.346	-.429	.184	.240	.055	-.651**	.543*	–
* Correlation is significant at the 0.05 level (2-tailed).								
** Correlation is significant at the 0.01 level (2-tailed).								

Pearson correlations among variables in VR condition

	1	2	3	4	5	6	7	8
1. Presence	–							
2. UserExperience	.836**	–						
3. preAttitudes	.561*	.491*	–					
4. postAttitudes	.619**	.569**	.915**	–				
5. dAttitudes	.221	.261	-.070	.339	–			

6. preScore	.106	.185	.251	.078	-.392	–		
7. postScore	-.376	-.148	.147	.014	-.310	.241	–	
8. dScore	-.407	-.267	-.057	-.046	.019	-.529*	.696**	–
* Correlation is significant at the 0.05 level (2-tailed).								
** Correlation is significant at the 0.01 level (2-tailed).								