UNIVERSITY OF IOANNINA
SCHOOL OF EDUCATION
DEPARTMENT OF PRIMARY EDUCATION

«Technological and Learning Affordances of Augmented Reality»

Panagiota Chalki

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DEDICATION

My research is dedicated to my father

ABSTRACT

Augmented Reality has shown positive effects in learning. By superimposing virtual objects to the physical environment, Augmented Reality (AR) offers students the opportunity to observe and interact with objects and events that are not visible in the real world to the naked eye. Therefore, it enhances students' motivations and helps them acquire better skills in the context of critical thinking and problem solving. However, the question raised concerns the affordances of Augmented Reality which make this technology more suitable for learning compared with other learning technologies. The aim of the current study is to investigate the effects of the technological affordances of Augmented Reality on the acceptance of this technology for learning purposes. The study investigates what users' technology acceptance is in terms of Intention, Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment, Mobile Self Efficacy, Sense of Presence and Simulator Sickness. In this context, two similar, in terms of affordances, technological approaches were chosen, namely Augmented Reality and Virtual Reality in order to compare the effects of each technology through an empirical study. More specifically, two environments were developed, regarding the electromagnetic waves of wireless devices, in Augmented Reality and Virtual Reality respectively, using Head Mounted Display devices. 47 undergraduate students, future teachers participated in the empirical study. The results showed positive responses regarding the participants' technology acceptance and sense of presence for all the factors mentioned above for both technologies, whereas very low level regarding the simulator sickness in both technologies. The comparison between the two technologies, showed that the participants demonstrated higher technology acceptance and sense of spatial presence in VR. On the other hand, the participants experienced a better immersion in AR. In addition, the results showed that the factor which had a direct effect to the Intention of the participants to use Augmented

Reality in learning was the Attitude they have towards Augmented Reality. This means that by enhancing the participants' Attitude it is likely to increase their Intention to use Augmented Reality. These findings should be taken into consideration by the educational policy to provide the teachers and the students of educational departments what is necessary in order to increase their Attitude towards Augmented Reality. This could be instructional materials and trainings about the advantages of Augmented Reality in teaching and learning, the ways Augmented Reality could be used for learning purposes supported by empirical demonstrations of gains, examples of educational Augmented Reality applications. They could also provide schools with the necessary resources needed to use Augmented Reality in schools, such as mobiles, tablets, Head Mounted Display devices and adjust the curriculum in a way that teachers would have the time needed to use Augmented Reality applications in their teaching.

Keywords: Augmented Reality, affordances, technological affordances, technology acceptance

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I: INTRODUCTION

Augmented Reality (AR) refers to technologies that enhance the sense of reality by superimposing digital information in the physical environment (Azuma, 1997). Augmented Reality technologies enable learners to interact with real objects of the physical world. However, high-quality user experiences are difficult to be created in order to contribute to the learning process (Dunleavy et al., 2009). Many studies have shown that once there is a high-quality interaction with the learning environment, students' emotional states contribute to better learning outcomes (Kai & Kim, 2008; Lee, 2012). Furthermore, research studies have shown that Augmented Reality features may increase students' motivation, interaction and satisfaction during the learning activities. The features of Augmented Reality may also enhance the sense of presence, flow, and satisfaction through sensory immersion, navigation, and manipulation (Kai & Kim, 2008). Similar conclusions are presented regarding 3D Virtual Learning Environments (Dalgarno & Lee, 2010). The positive effect of Augmented Reality on emotions may improve students' cognitive processes and performance. However, not many empirical studies have been conducted to prove or decline those claims (Chiang & Sosai, 2012; Dalgarno & Lee, 2010).

Regarding the equipment needed to use AR applications, a variety of displays and hardware to present digital objects on the physical environment exists. The types of AR widely recognized by the scientific community include head-worn glasses (e.g., Head Mounded Displays, HMD), handheld computers (e.g., tablets and smartphones), and spatial projection display systems (Sieberfeld et al., 2016). A distinction is also made as to whether AR systems integrate the physical and virtual worlds in a fully digital way, or place digital objects on top of the physical environment using transparent technology that can still be used in combination with digital content. AR also requires a reference point in the physical world to be used for navigation, positioning, and orientation. This can be based on markers that can be represented as images: specific codes (e.g., QR Codes) found on objects of the physical environment. Another category of AR is location-based, enabled by the user's location provided by interior tracking system or a Global Positioning System (GPS). Finally, AR uses two-dimensional and three-dimensional object recognition to collect information about users or the physical environment. Marker-based Augmented Reality (59.38%), location-based Augmented Reality (21.88%), and marker-free AR (12.5%) are by far the most commonly used AR types in learning and education (Bakka et al., 2014). Today's tools and equipment make it easier to create AR applications that are attractive compared to the past when the tools were expensive and hard to use (Billinghurst et al., 2015). However, specific types of AR such as head-worn glasses are still expensive and thus hard to be used in the learning process.

Over the last few decades various learning technologies (e.g., Virtual Reality, Augmented Reality, etc.) have been proposed for the learning process. The main question that arises is by what criteria a learning technology should be chosen in the context of teaching. When and what kind of learning technology would be useful for a specific teaching? It was quite often, when something new was created regarding learning technologies that a lot of people would use it, as it was impressive, without a critical overview of its necessity. The concept of affordances could help to answer this question.

The term affordance originates in Gibson’s (1977) theory of affordances. In Gibson’s original ecological psychology studies, affordances are defined as latent cues in environments, such as substances, surfaces, objects, and places that hold possibilities for action. Later, researchers defined the terms learning (or educational) affordances and technological affordances. More specifically learning affordances are defined as the intended actions permitted by a certain environment (Wolfswinkel et al., 2013), whereas the technological affordances are defined as the technological latent cues of a technological tool. For example, a whiteboard’s technological affordances refer to the fact that we can write and draw on it, whereas its learning affordances arise when it is used for pedagogical purposes.

Specifically, regarding AR, we follow Craig's approach (2013) for the technological affordances as well as the technological affordances proposed by Mikropoulos & Natsis (2011):

1. The physical world is augmented by digital information superimposed on a view of the physical world.
2. The information is displayed in registration with the physical world.
3. The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.
4. Immersion.
5. Presence.
6. Autonomy.
7. Natural semantics.
8. Multisensory channels.
9. Physical representation of the user in the real environment.

In the relative literature that has been reviewed, very few studies include definitions regarding the learning and technological affordances in AR. More specifically, some studies which mention the term affordances for AR, do not specify them, whereas in some others the term affordance is used for learning approaches or other pedagogical concepts such as inquiry learning or conceptual understanding (Akçayır & Akçayır, 2017). Furthermore, with respect to the existing research studies, regarding the AR affordances, a distinction of the technological and learning affordances as proposed by Mishra & Koehler (2007) was not found. Hence, no empirical studies were found regarding the investigation of the technological affordances of AR.

The aim of this study is to examine the effects of AR technological affordances (which determine the learning affordances) on the acceptance of Augmented Reality technology for learning purposes. Two similar, in terms of affordances, technological environments were chosen, namely Augmented Reality and Virtual Reality in order to compare the effects of each technology through an empirical study. More specifically, the study investigated what the users' technology acceptance is in terms of Intention, Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment, Mobile Self Efficacy, Sense of Presence and Simulator Sickness regarding both Augmented Reality and Virtual Reality applications.

The contribution of this dissertation refers to the scientific field of Augmented Reality in education as it provides the first results in the field from an empirical study regarding the effect of the technological affordances of Augmented Reality for learning purposes by using Head-Worn Glasses and by comparing the effects between Augmented Reality and Virtual Reality in terms of technology acceptance, sense of presence and simulator sickness.

This dissertation is structured into five chapters.

The first chapter is the introduction.

In the second chapter the literature review is presented. The term Augmented Reality is defined, the architecture of Augmented Reality is presented, the History of Augmented Reality is described, and the types of Augmented Reality are analyzed. Subsequently, Augmented Reality for learning purposes is extensively presented, followed by a discussion regarding the student motivation and examples of Augmented Reality applications in learning processes. Next, the term affordances is discussed – followed by the definition of the learning and technological affordances of Augmented Reality and VR. Finally, the learning affordances mentioned in Augmented Reality studies are presented.

The third, fourth and fifth chapters refer to the empirical study.

In the third chapter the research questions are stated and the methodology that was followed is presented. Information is given about the participants, the Augmented Reality and Virtual Reality applications that have been developed and the Augmented Reality and Virtual Reality activity. Subsequently, the data collection as well as the data analysis are described.

In the fourth chapter the results of the study are presented.

Finally, in the fifth chapter a discussion of the results is presented followed by conclusions and suggestions for future work.

Note: This thesis has been checked for plagiarism with turnitin.

CHAPTER II: AUGMENTED REALITY IN EDUCATION

2.1. DEFINING AUGMENTED REALITY

Researchers in the fields of computer science and educational technology have widely defined the term of Augmented Reality (AR) (Azuma, 1997; Caudell & Mizell, 1992; Craig, 2013; Liarokapis & De Freitas, 2010). Mizell and Cuadell first defined the term Augmented Reality (1992) as used to augment the visual field of the user with information necessary in the performance of the current task. Moreover, in the paper of Takemura et al. (1994) one of the fundamental definitions was appeared and it was then divided into two different approaches: broad and restricted. The broad approach refers to AR as "augmenting natural feedback to the operator with simulated cues." The restricted approach, on the other hand, refers to the technological aspect and defines AR as "a form of virtual reality where the participant's head-mounted display is transparent, allowing a clear view of the real world."

AR enables the user's interaction with the virtual images that are present in the context of the real world (Chen & Tsai, 2012). AR overlays computer-generated sensory information including video, audio, imagery, and GPS data on a real direct or indirect view of an actual real-world environment (Wu et al., 2013). As a result, AR would provide image transfer information to the user through electronic devices, allowing them to explore the merging of physical and virtual worlds (Klopfer & Sheldon, 2010). Using visual communication will also improve the user experience (Dunleavy, Dede, & Mitchell, 2009).

Augmented Reality AR is generally referred to as a technology-aided extension of an experience that encompasses all sensory perceptions (Azuma, 1997; Milgram & Kishino, 1994). The digital display of computer-generated content, including words, images, or videos, often is referred to as augmented reality. AR is a supplement to the physical world that enables users to explore virtual and real layers in the same space while also assisting them in performing activities in the actual world. Augmented reality technologies merge the physical and digital worlds and allow real-time interaction.

AR can be defined as a representation that combines virtual images with objects from the real world (Vyas, 2015). To better understand this technology, it is helpful to look at earliest examples to see how AR has been evolved in empirical studies. Despite of getting its roots in the 1960s with Morton Heilig's Sensorama Simulator, which was the first true multi-sensory simulator, augmented reality is a comparatively recent concept (Gigante, 1993). It is not till the 1990s that the word "augmented reality" was invented. Tom Caudell and David Mizell first used it while working on a Head - Mounted Display (HMD) monitor for Boeing, that showed simple wire frames, template outlines, designators, and text displayed over the physical world (Caudell, & Mizell, 1992).

Azuma wrote "A Study of Augmented Reality" in 1997 that was the first systematic paper exploring the various applications for AR at the time. Later, a definition of AR was presented by him and it was based on different features as a system that described and fulfills the mentioned below characteristics:

- A combination of real and virtual worlds.
- Real-time interaction.
- Accurate 3D registration of virtual and real objects.

Azuma (1997) has defined augmented reality as a variation of Virtual Environments (VE), or Virtual Reality (VR). However, where a VE will fully immerse a user in a virtual world, AR supplements reality, instead of completely replacing it.

The physical world is highlighted as the place where virtual objects are added. This is a significant difference with VR, in which the user interacts exclusively with a digital world. Nevertheless, the two technologies can be seen on a continuum, with AR and VR representing a sliding scale of mixed reality, with AR defining real-time perceptions of the physical world, where computer-generated sensory input such as audio or graphics as a surface or reflection, has been (to a lesser or greater extent) augmented, enhanced or enriched (Munnerley et al., 2012).

Mixed Reality is a definition pulled by Milgram and Kitshino (1994) to describe the continuum among the real, physical world and the virtual environment. Mixed reality refers to the area between a virtual environment in which all data are digitally simulated and a totally physical world where no content is digitally simulated. AR belongs to the category of mixed reality, which includes both real-world and digital simulations (Azuma, 1997; Milgram & Kitshino 1994).

Klopfer (2008), on the other hand, opposed a restricted definition of augmented reality, stating that the concept should be applied to any technology that combines real and digital information in a meaningful way. Today, since virtual reality can be developed and implemented using a range of devices such as desktops, tablets, hand - held devices, and head-mounted monitors, it makes more sense to use a broad definition of the term.

In order to understand the classification system of augmented reality, it's necessary to define the extent to which reality is augmented. Milgram et al. (1994) proposed Reality – Virtuality continuum that ranges from real environment to virtual environment (figure 1). The graphical representation of mixed reality is described as a situation in which physical and digital world objects are presented together (Milgram et al., 1994).

Figure 1. Reality-Virtuality continuum by Milgram et al. (1994).

AR, according to the continuum, is a mix of physical and virtual objects, where physical objects are more that the virtual. Augmented Virtuality (AV), on the other hand, is characterized as a situation in which a virtual environment is supplemented by real-world elements and contains more virtual content.

The diagram is used to differentiate the concept of AR and a broader concept of Mixed Reality (MR). The physical and virtual worlds are at opposite ends of a continuum. The mediators of this continuum are AR and VR.

AR is a new concept for interacting with devices that takes into consideration users' senses and abilities (Mackay, 1996). He also divided AR applications into three groups: ‘users,' ‘objects,' and ‘environment’ (Table 1).

Table 1. Examples of Augmented Reality Approaches with relevant technologies and applications (Mackay, 1996)

Augment	Approach	Technology	Applications
Users	Devices worn on the body	VR helmets; Goggles; Data gloves	Medicine; Field service; Presentation
Physical objects	Embedded devices within objects	Intelligent bricks; Sensors; GPS	Education; Office facilities; Positioning
Environment surrounding objects and users	Project images and remote recording	Video cameras: Graphics tablets; Bar code readers; Scanners; Video Projectors	Office work; Film-making; Construction; Architecture

To prevent restricting AR to any particular technology, Azuma (1997) characterized AR as a technology which has the three components described above. These three features are not limited to specific display systems like head-mounted displays (HMD). Furthermore, they are not restricted to our sensory perceptions, but could affect all our senses, like touch, hearing or smell (Bederson, 1995; Novotný, Lacko, & Samuelčík, 2013). Researchers will speculate more about whether instruments like communication tools are enhancements to certain other human skills (like cognition). Technology integrates knowledge in virtual content into the physical world in real-time performance according to Liarokapis and De Freitas (2010). The biggest argument leveled at this concept is how virtual information and the physical world are the only aspects of AR, that is if they are simply combined, or if they have any other connections.

"Augmented reality bridges the gap between the real and the virtual in a seamless way" according to Lee (2012, p.13). It may be incorporated in instruction and take different ways to suit a variety of purposes.

Researchers have introduced shortened definitions of AR in the last decade that are built upon the single characteristic of overlaying visual information onto physical objects. Sayed, Zayed, & Sharawy (2011), for instance, claim that AR only attaches digital elements to physical scenes. Chen & Tsai (2012) claim that AR allows interactions with virtual objects in two dimensions and three dimensions in a real-world environment, and Cuendet et al. (2013) claim that AR is simply a projection of virtual objects on physical objects. AR, from the other side, is not restricted to a sensory perception or to special display devices such as HMDs, laptops, and mobiles; it also provides the capacity to address other senses as well as the potential to replace real objects by overlaying digital ones. This is called mediated or diminished reality (Krevelen, 2010). AR can be considered as an extension of VR (Wojciechowski & Cellary, 2013).

In AR, technology serves a critical role. AR applications can be used in both in formal informal educational environments because they enable students to communicate with actual physical items by creating location awareness. The situation where people use a large amount of information and physical elements while having limited access to virtual objects is referred as lightly augmented reality. A heavily augmented reality, on the other hand, includes frequent access to virtual content (Wu et al., 2013).

In the past decade, technology has advanced. Although the basic concept of augmented reality has not differentiated, the methods it could be used have. Craig (2013) examines AR's principles, hardware, devices, information, communications, mobility, and implementations, as well as the potential of the technology. He describes augmented reality as a platform that incorporates a variety of technologies rather than a single application. He uses Azuma's (1997) concept as a starting point, then goes on to extend and clarify his own concept of AR. "Augmented reality" is defined as a format in which digital content is superimposed on the natural world in both spatial - temporal registration with the real environment and interacts in real – time" (Craig, 2013). This classification adheres to Azuma's (1997) three key features of AR, with the exception that AR must be regarded a medium rather than a particular technology. Craig provides a list of main elements of AR (Table 2) that go beyond Azuma's three categories. Craig emphasizes on AR to construct an environment by combining physical and digital objects and interact to create an experience.

Table 2. Key aspects of augmented reality (Craig, 2013)

Key aspects (ingredients) of augmented reality:
1. The physical world is augmented by digital information superimposed on a view of the physical world. 2. The information is displayed in registration with the physical world. 3. The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world. 4. The AR experience is interactive, that is, a person can sense the information and make changes to that information if desired. The level of interactivity can range from simply changing the physical perspective (e.g., seeing it from a different point of view) to manipulating and even creating new information.

AR is becoming a popular research topic in the last decade, especially in education. One of the main reasons for AR's widespread use is that it no longer requires specific and expensive devices, such as HMDs. Computers and handheld devices can also be used instead. As a result, using AR technologies is no longer as complicated as it was. It is also met at all levels of education and training. (Chiang, Yang, & Hwang, 2014b; Kerawalla et al., 2006; Ferrer-Torregrosa, et al., 2015). However, due to its comparatively high cost, a wide use was not possible until the introduction of handheld devices (Garzón, Pavón, &

Baldiris, 2019). Since 2010, the use of handheld devices has resulted a rapid increase in the quantity of AR application for education, including innovative methods to enhance learning settings (Ozdemir et al., 2018).

2.2. A CONCEPTUAL ARCHITECTURE OF AR

The purpose of the AR conceptual architecture is to determine the relation among the factors used in the development of AR and to comprehend its concept. The established AR interactions and features are reflected and abstracted in this AR structure (Figure 2). A person who can manage and monitor the AR system is referred as an AR user. The relation between the user and the AR interface (e.g., changing the system's position) or interactive content is represented by the arrow under the word interaction. An AR system (e.g., handheld device) may either attach to a server to load data or handle data analysis on the system itself. The system's information regarding the virtual objects presented on the AR device is referred to as virtual content. The initial material displayed on the AR device with no inherent changes is referred to as real content. Physical world is referred as the real environment (Liang, 2015)

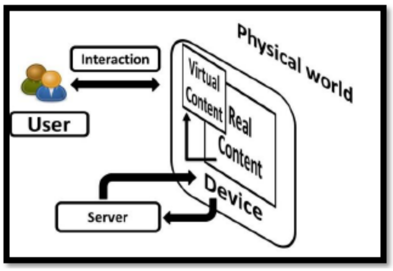

Figure 2. Generic Augmented Reality Conceptual Architecture (Liang, 2015)

2.3. HISTORY OF AR

Augmented reality has a long tradition, going back to the 1960s, when the first device was being used for both virtual and augmented reality" (Lee, 2012). Morton Heilig, a director of photography, created Sensorama, a multi-sensory system that featured sights, noises and movements in 1962 (Kipper & Rampolla, 2013). Ivan Sutherland developed

“The Sword of Damocles” in 1968, which was the world's first digital and virtual reality device (Kipper & Rampolla, 2013). Late in 1975, Myron Krueger was the first one to develop a device called Videoplace that enabled users to communicate with virtual environments (Kipper & Rampolla, 2013). Tom Caudell and David Mizell invented the word virtual reality in the 1990s (Kipper & Rampolla, 2013; Lee, 2012). The word spread as a result of activities on the Adaptive Neural System Research and Development project at Boeing Computer Services. Jun Rekimoto produced the NaviCam, an AR invention which is still in operation nowadays, in 1996. (Kipper & Rampolla, 2013). The design improved on the concept of the 2D matrix generator. The key concept was to merge natural and simulated worlds by having the device recognize actual locations or artifacts as digital resources. The design improved on the concept of the 2D matrix generator. The key concept was to merge natural and simulated worlds by having the device recognize actual locations or artifacts as digital resources. Total Absorption, the first AR corporation, was established in 1999 (Kipper & Rampolla, 2013). A variety of goods were created by the firm. Bruce Thomas then developed a virtual technology variant of a famous game in 2000 (Kipper & Rampolla, 2013). Reitmayr and Schmalstieg developed the very first mobile AR device in 2001. (Kipper & Rampolla, 2013). Mathias also developed the first method for monitoring 3D on handheld devices with a video in 2004 (Kipper & Rampolla, 2013). Nokia began a smartphone augmented reality technology (MARA) venture two years later in 2006. (Kipper & Rampolla, 2013). The application used cameras to capture a trigger and then displayed a variety of text and graphics in live time to the user. AR technology has grown in popularity in the last decade. Mobilizy developed the Wikitude World Browser app in 2008, which is based on GPS and compass info (Kipper & Rampolla, 2013). Using a mobile camera, the user could search Wiki page data in actual time. SPRXmobile, like Wikitude World, introduced Layar in 2009 (Kipper & Rampolla, 2013). In 2012, major corporations and companies including Toyota, Nissan, BMW, and Mini adopted AR technologies to promote their products and provide consumers with a full 3D image of their products (Kipper & Rampolla, 2013). Iron Man, Star Wars, Transformers, and Star Trek have all used AR to promote their films. Lego shops use AR to offer customers animated versions of their Lego toys. By taking activities to life and offering virtual environments in the parks, Disney World merged AR to make the Disney visit more exciting for their visitors (Kipper & Rampolla, 2013). Disney World also incorporates AR technologies into their products; for example, some smartphone applications can turn child's books into interactive 3d visualizations that perform or say a story. Disney Fans have produced a magical mirror for little beauty queens to promote their outfits in their shops (Total Orlando Blog, 2013). AR is still evolving and taking place in a variety of fields today. The benefits of augmented reality go beyond movies. Users can see the objects they are assembling in 3D modeling using AR technologies. Google spent $542 million in Magic Leap Inc., an AR company, in 2014, and had high expectation for future applications of the AR technology (Olivarez-Giles, 2016).

2.4. TYPES OF AR

AR uses a variety of displays and hardware to present the virtual information superimposed to the physical environment. The types of AR that are widely recognized by the scientific community are the Head-worn glasses (e.g., HMDs), hand-held computers (e.g., tablets and smartphones), and spatial projection display systems (Syberfeldt et al., 2016). A differentiation is also made whether an AR system integrates the physical and virtual world into an entirely digitally manner or simply superimposes digital objects on the physical environment by the use of transparent technology that still allows to see the physical environment in combination with the digital content. AR also needs a reference point in the physical world to be used for navigation, positioning and orientation. This can be based on markers which can be represented like images-special codes (e.g., QRcodes) that are located on elements in the physical environment. Another category of AR is location based, which is enabled by a user's location and is provided whether by interior tracking systems or global positioning system (GPS). The majority of spatial AR is used by projection-based systems.

2.5. AR IN LEARNING

Research has demonstrated, that augmented reality technology has many benefits when used for learning purposes (Cheng & Tsai, 2013). Researchers and teachers are excited about using new technologies in teaching and learning like AR and VR (Bower, 2008; Dalgarno & Lee, 2010; Dunleavy et al., 2009; Kye & Kim, 2008). Interaction and the sense of presence of these technologies are supposed to enhance satisfaction, knowledge, and be helpful in learning activities that require spatial ability, experimentation, and teamwork, among others (Dalgarno & Lee, 2010; Dunleavy et al., 2009). Moreover, some researchers emphasize on AR affordances, including its ability to promote kinesthetic learning and memory cognitive processes (Chien, Chen, & Jeng, 2010; Dunleavy et al., 2009).

AR refers to those technologies which increase the sense of reality by combining virtual object and physical environments (Azuma, 1997). Students can interact in those environments with physical objects by processes that have not been discovered yet (Bujak et al., 2013; Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). However, a high-quality user experience is difficult to achieve, and interaction with the learning environment should help rather than hinder the learning process (Dunleavy et al., 2009; Zaharias, 2003). Many studies have reported that when interacting qualitatively with the learning environment, students' emotional states contribute to the improvement of learning outcomes (Billingshurst, 2003; Dalgarno and Lee, 2010; Kai and Kim, 2008; Lee, 2012) In addition, researchers have shown that AR increases students' motivation, engagement, and satisfaction in learning activities. In this context, Kye & Kim (2008) in their conceptual model argue that AR characteristics such as manipulation and navigation may contribute to the emergence of feelings of presence, flow and satisfaction. Similar to this conceptual model, Dalgarno & Lee (2010) propose their learning model regarding 3D virtual learning environments. Both have concluded that the positive effect of AR on emotions can improve cognitive processes and students' performance. What is lacking, however, is empirical research to support these theoretical claims (Cheng & Tsai, 2012; Dalgarno & Lee, 2010; Kai & Kim, 2008).

AR helps students to engage authentically in the physical environment (Dede, 2009). By combining virtual with real objects, it makes it easier to observe AR events that are not easily visible to the naked eye (Wu et al., 2013). Therefore, it motivates students and helps them acquire better skills (Sotiriu & Bogner, 2008). According to Dunleavy, Dede, and Mitchell (2009), the most important benefits of AR are critical thinking, problem solving, and the unique ability to create an immersive hybrid learning environment that combines digital and physical objects. It facilitates the development of processing skills and interactive collaboration. Akayar et al. (2016) in their study show that AR technology improves the experimental skills of college students and gives them a positive attitude towards experimental work. In the literature, some researchers associate AR with some limitations. For example, Lin et al. (2011) and Akçayır & Akçayır (2017), argue that students have some difficulties in using AR and they find it complicated as they cope with technical problems. A well-designed interface for students and guidance, could help the students to deal with those technical problems. The devices used for AR applications could cause more technical problems (Wu et al., 2013). In addition, Yu et al. (2009) argue that some devices related with AR such as HMDs, are not easy to manage and that AR technology needs to be smaller, lighter, more portable, and fast enough to display graphics. Except for technical limitations, Munoz-Cristobal et al. (2015) show that effective use of AR in education requires excessive lecture time. A considerable amount of research has been conducted regarding AR in the field of education. However, despite the fact that many AR studies have been published, the usefulness associated with the educational benefits of AR has only recently been examined in detail (Cheng & Tsai, 2013; Martin et al., 2010).

Flow represents a state of complete absorption or interaction with activities that act as motivators for daily activities such as work, sports, and education (Chan & Ahern, 1999; Choi & Baek, 2011; Kye & Kim, 2008). Motivation encouraged by the flow state allows learners to engage in activities without achieving obvious enhancements (Davis, Bogozzi, & Versace, 1992). This spontaneous learning is considered to be the best way to learn (Ghani & Deshpande, 1994), and the main challenge in education is to facilitate the flow of learners. In this regard, studies of web-based learning environments have shown that there is a positive correlation between the flow conditions and learning outcomes that students can reach when using those environments (Liao, 2006; Shin, 2006; Webster, Trevino, & Ryan 1993). Studies analyzing student performance in multi-user virtual and game-based learning environments have also shown positive results (Faiola et al., 2013; Papastergiou, 2009). Therefore, it is reasonable to expect that emerging technologies such as AR will also promote learner flow conditions and, as a result, help learners achieve better results.

Interactive technologies like AR are potentially effective in enhancing learning outcomes (Conole & Dyke, 2004). Therefore, an active area of research is the examination of learning affordances provided by these emerging technologies in the field of different domains (Dalgarno & Lee, 2010; Mikropoulos and Natsis, 2011).

To create an AR environment, a virtual representation of a part of the real environment is needed to be designed. Most AR environments are made up of realistic objects that provide the highest level of reality possible without the need to create detailed 3D models. In an AR environment, users can communicate directly and naturally with virtual objects by manipulating real objects without the need for expensive input devices (Wojciechowski et al., 2004). Also, unlike virtual environments where users communicate via avatars, AR allows users to interact directly with each other. AR applications provide better possibilities for learning by doing through physical movements in rich sensory spatial contexts (Dunleavy, Dede, & Mitchell, 2009). Therefore, users have the opportunity to conduct experiments on digital objects in the real world, which supports situated learning, namely learning must take place in the context in which it applies (Lave & Wenger, 1991). AR enables students to combine the learning environment with the physical environment and apply the knowledge and skills they have learned.

In an AR environment, learning content can be presented in meaningful and concrete ways. Students can play an active role in a variety of activities with interactive educational scenarios developed, based on learning by doing. The experience gained by the learner during the learning process in the AR environment can be the basis for classroom reflections and group discussions. The main aspects of education provided by the AR environment are spatial ability, practical skills, conceptual understanding, and inquiry-based activities (Cheng & Tsai, 2012). The implementation of AR in education is followed by cost reduction due to the replacement of expensive resources, such as laboratory equipment and supplies, with their virtual counterparts. An important benefit of AR environments is safety, as unskilled students can explore potentially dangerous situations without risk of injury or damage expensive equipment.

There are several possible applications of AR settings in education (Walczak et al., 2006). They can be used to teach about objects and phenomena that cannot be seen with the naked eye (e.g., molecular movements), simulate potentially dangerous situations (e.g., chemical reactions), and visualize abstract concepts (e.g., magnetic fields). In addition, the level of complexity of the phenomena presented can be reduced to make it easier for students to acquire knowledge about the underlying concepts. AR environments can be used in a wide range of fields ranging from natural sciences (e.g., chemistry, physics, biology, astronomy), computer and information science, mathematics, engineering (egg, mechanical, electrical, biomedical), humanities (e.g., history, linguistics, anthropology). Researchers (e.g., Chen & Tsai, 2012; Squire & Klopfer, 2007) have suggested that educational AR applications could provide students with a more engaging learning environments without diminishing the authenticity of the real world. More recently, researchers have turned their attention to the application of AR on portable devices such as mobile phones (Azuma, Billinghurst, & Klinker, 2011; Martin et al., 2010). With the features of AR, ubiquitous computing, and portability (Papagiannakis, Singh, & Magnenat-Thalmann, 2008), the application of mobile AR in education is increasing rapidly. In the Horizon 2011 report, the potential educational applications of mobile AR began to attract the attention of researchers, and more empirical studies were requested in this regard (Johnson et al., 2011). Martin et al. (2010) also confirm this perspective based on a thorough study of technology trends in education and argue that the practical use of mobile AR in education would become a significant field of research in the near future. Moreover, Azuma et al. (2011) indicate an urgent need for more research on how to use wearable devices to deliver a mobile AR experience to users.

Furthermore, AR with handheld devices has revealed great potentials to support collaborative face-to-face learning and improve social interactivity among group of students (Behzadan, Iqbal, & Kamat, 2011; Klopfer, 2008). According to Li et al. (2011), handheld AR devices allow students to explore the outside environment and interact with other student through the guidance of AR-supported information and therefore construct knowledge. The use of AR simulations allows students to experience scientific phenomena (e.g., elastic collision) as well as underlying scientific constructs (e.g., kinetic energy and momentum) that are not easily observable in the physical environment and support them with more authentic learning practices (Klopfer & Squire, 2008). Klopfer and Squire (2008) also mention several advantages of using mobile or portable devices, including portability, social interactivity, context sensitivity, and others. In summary, it is implied that a mobile AR platform, with its mobility and ubiquity, may enhance the interactive experience for students without the limitation of specific locations (e.g., desktops).

2.6. AR APPLICATIONS

AR technologies are used in many educational fields. Biology is the main field in this regard. Except for biology, considering also physics and chemistry, it can be said that AR is a tool frequently used in science education. This may be related to the fact that scientific topics include a multitude of concrete concepts (Karal & Abdüsselam, 2015). AR presents suitable environments to facilitate understanding of scientific concepts using 3D models. Therefore, students have the opportunity to directly observe specific concepts instead of visualizing them (Furió, et al., 2013). Another possible explanation for the widespread use of AR in science education is that AR has been shown to be effective when applied to laboratory experiments (Akcayir et al., 2016; Enyedy et al., 2012; Ibáñez et al. 2014; Lin et al. 2013;), ecology (Wrzesien & Alcañiz Raya, 2010), field trips (Kamarainen et al., 2013), mathematics and geometry (Blake & Butcher-Green, 2009), science (Chang, Wu & Hsu, 2013) and in general when students can see things that cannot be seen in the real world without a specialized device. Additionally, students do not have to imagine what is happening around them but can actually see it (Furio et al., 2013), which also means AR is effective at teaching abstract or complex concepts. In fact, the literature includes many AR studies conducted on various scientific topics such as ecology (Hsiao, Chen, & Huang, 2012), electrostatics (Echeverría et al., 2012), electromagnetics (Ibáñez et al., 2012) molecules (Cai, Wang, & Chiang, 2014), elastic collision (Wang et al., 2014) and momentum (Lin et al., 2013).

Following the domain of "Science" the next field of education which AR is used the most is "Humanities and Arts". Research in this area of education has focused on language learning (Liu & Tsai, 2013) visual arts and painting (Chang et al., 2014; Di Serio, Ibáñez, & Kloos, 2013;) and culture and multiculturalism (Furió et al., 2013). AR is widely used in language learning due to its ability to augment information and combine it with contextual information to provide a new language learning experience. On the other hand, thanks to the possibility of adding virtual information to the real world, augmented reality has been applied to painting to provide an enhanced experience. AR is also used for non-formal education settings such as museum education (Chang et al., 2014), library education (Chen & Tsai, 2012) or staff training (Pejoska, et al., 2016). AR technology is also used in fields such as language teaching, special education, early childhood education, history teaching and astronomy teaching. There are also studies on various topics such as teacher training (Muñoz-Cristóbal et al., 2014), arts education (Di Serio et al., 2013) and robotics training (Tanner, Karas, & Schofield, 2014). There are also studies examining the impact of AR on applied learning domains such as assembly, repair, and maintenance (Gavish et al., 2015; Westerfield, Mitrovic, & Billinghurst, 2015). The above show that AR is a technology that can be used in education and training in a wide variety of fields.

2.6.1. EXAMPLES OF AR APPLICATIONS IN THE LEARNING PROCESS

Science - Chemistry

The first example presented regarding an AR application for learning, is from the field of science. The AR application refers to chemical experiments. It consists of a desktop computer with a monitor, webcam, and a set of cardboard markers. A webcam is placed above the monitor. It captures the area where the set of cardboard markers are placed. Students are seated in front of a monitor and are free to manipulate the markers. The webcam image displayed on the screen is flipped horizontally. This allows students to see their mirror image on the monitor, augmented with digital objects. Thus, the students have the illusion that virtual objects exist in their environment (figures 3-5) (Wojciechowski & Cellary, 2013).

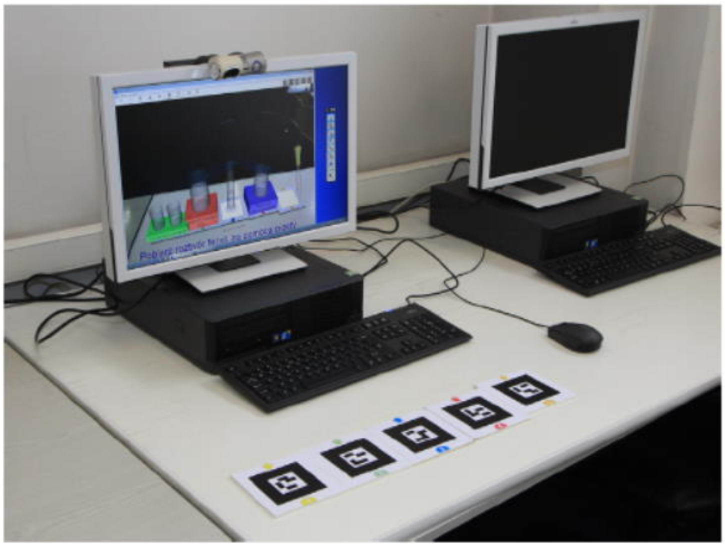

Figure 3. AR installation – a desktop PC with a monitor, a webcam, a set of physical markers

Figure 4. Mirrored image augmented with virtual objects – direct interaction of students with virtual objects

Figure 5. Students carrying out a chemical experiment by manipulating real objects

Science laboratories

Five different applications have been developed for five different physics experiments. The applications use videos, graphics, and links to additional documents. For example, the Wheatstone Bridge experiment uses two components. By clicking on the video symbol, a video (four minutes long) explains how to conduct the experiment. A simulation link is provided via the yellow button on the artificial label, which allows students to virtually experiment and measure samples (figures 6-8) (Akçayır et al., 2016).

Figure 6. Interface of the AR application

Figure 7. Example of providing AR information (video)

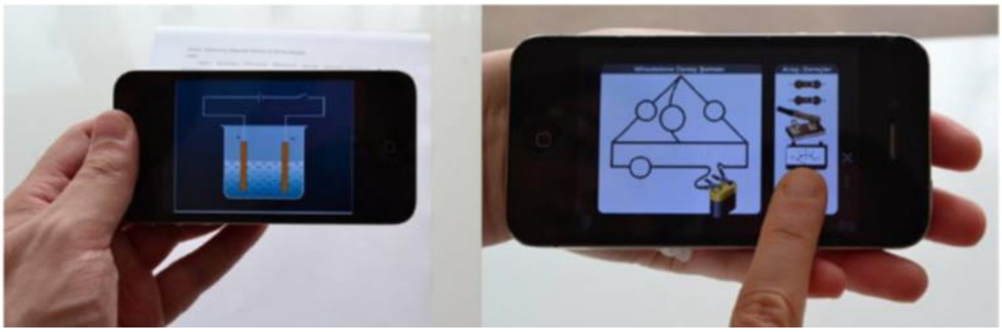

Figure 8. Example of providing AR information (animation and simulation)

Science - Physics

In this AR application, the magnetic field is visualized by virtual lines (figure 9) (Santos et al., 2014).

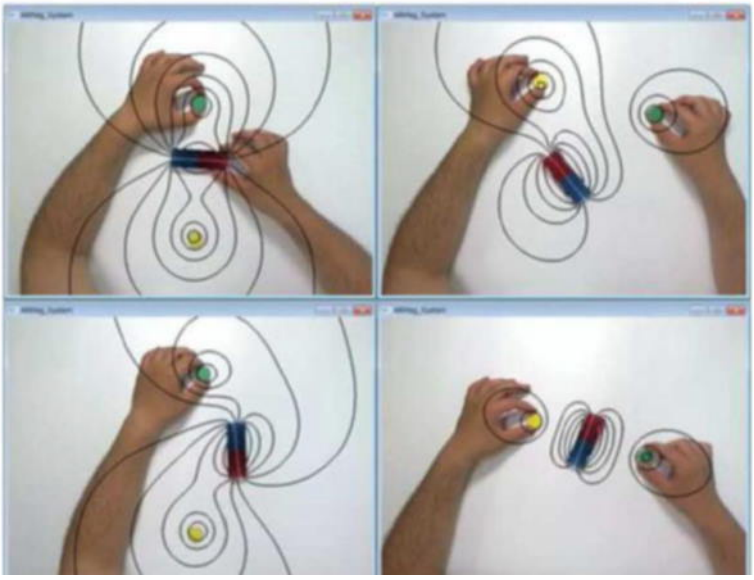

Figure 9. Virtual lines representing magnetic field lines as augmented in the physical environment

Science - Astronomy

Based on kinesthetic learning style theory and traditional astronomy teaching strategies, a mobile digital armillary sphere (MDAS) using augmented reality was developed for use in astronomical observation training (figures 10, 11). MDAS enables the use of visual processes and movements similar to those that occur in real outdoor conditions, thereby overcoming existing learning limitations (Zhang et al. 2014).

Figure 10. The operations of prompt constellation painting in the MDAS

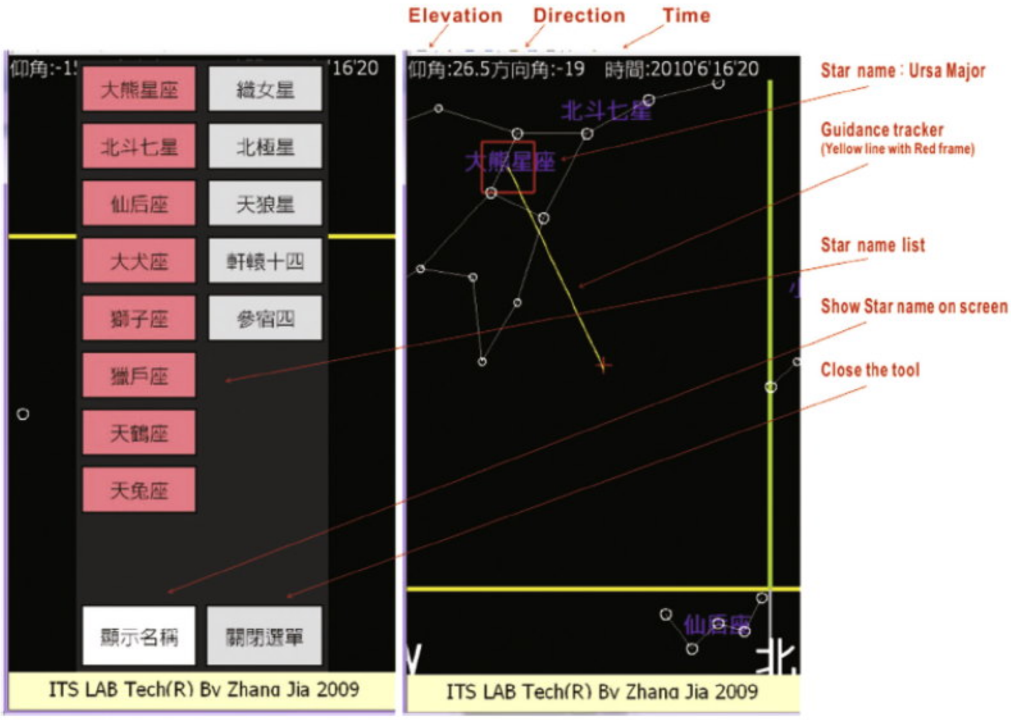

Figure 11. Guide tool modules

Pedestrian Navigation

This AR application provide the user with AR models, information text, old photographs, and digital maps. The general view of the proposed territorial landmarks is displayed on a digital map with automatic adaptation of the territorial vision according to the position of the device. In addition, it is possible to create different spatial scales of the presentation according to the user's needs (figure 12) (Nagata et al., 2017).

Fig. 3. Structure of the mobile application.

Figure 12. Structure of the mobile application

Building design

In this AR application, users can receive instructions from a virtual avatar and scan a tracking image attached to building elements to access information to design and assemble a building. Students can use their mobile devices (smartphones or tablets) to scan QR codes, then turn to the avatar to watch the associated instructional videos. They can also use their mobile devices to scan a QR code and access information about the design and performance of model building elements. Information is visually superimposed on each building element as soon as the tracking image attached to that element is scanned and detected by the camera of the mobile device (figures 13-15) (Shirazi & Behzadan, 2015).

Figure 13. Students used location-based channel to receive step-by-step descriptions from a virtual avatar

Figure 14. 3D virtual information displayed over the view of a real model building element

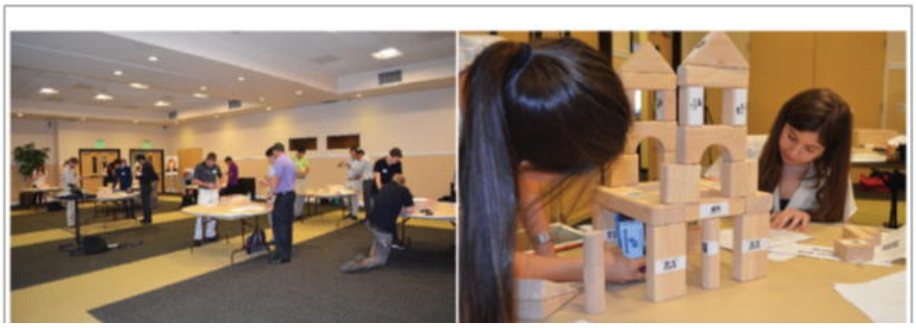

Figure 15. Student receiving instructions from the virtual avatar (left) scanned the tracking image attached to each building element to access information

Geometry

Construct3D is a 3D geometric construction tool based on the collaborative augmented reality system Studierstube. It uses a Stereoscopic HMD and Personal Interaction Panel (PIP), a two-handed 3D interaction tool that support the interaction with a 3D model (figure 16) (Kaufmann & Schmalstieg, 2006).

Figure 16. Users during interaction with the augmented 3D object

Medical education

This application includes multimedia elements consisting of 3D video animations and a 3D model of human anatomy (figure 17). The mobile device can display an image from a book and augment the virtual contents of a 3D human anatomy model (Küçük, Kapakin, & Göktaş, 2016)

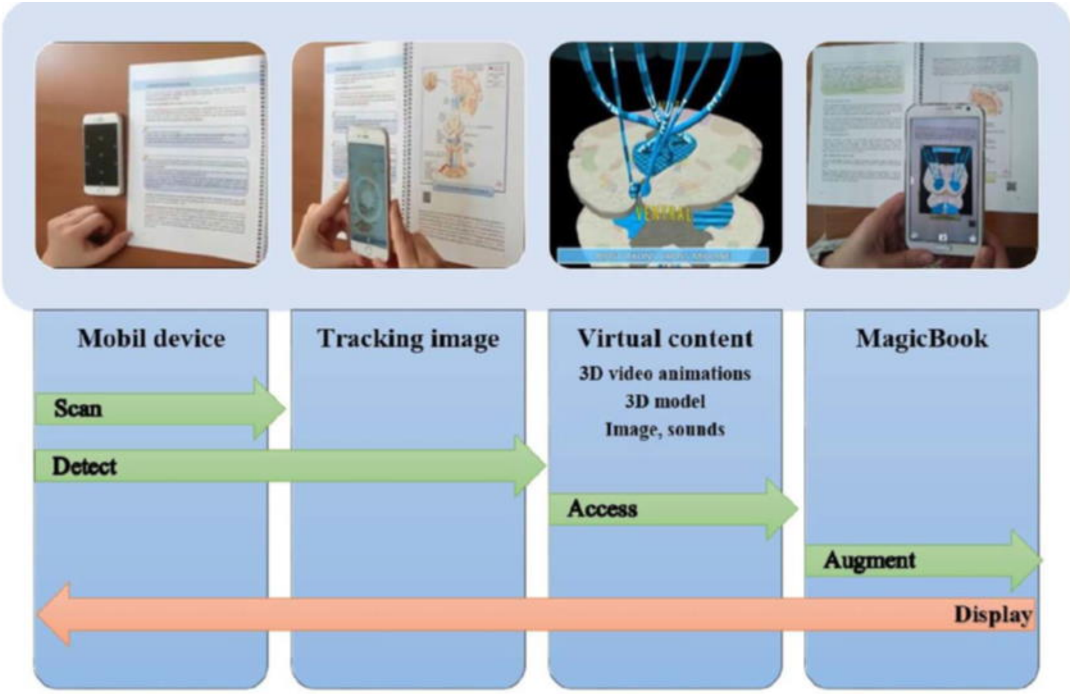

Figure 17. The process of the AR application

Neurosurgery

This AR application is related to neurosurgery and was developed using AR environment and the leap motion hand controller. The platform for this simulator is mobile based. A mobile is paired with a set of 3D glassed to give users a stereoscopic view of the AR environment (figures 18, 19) (Wright, Ribaupierre, & Eagleson, 2017).

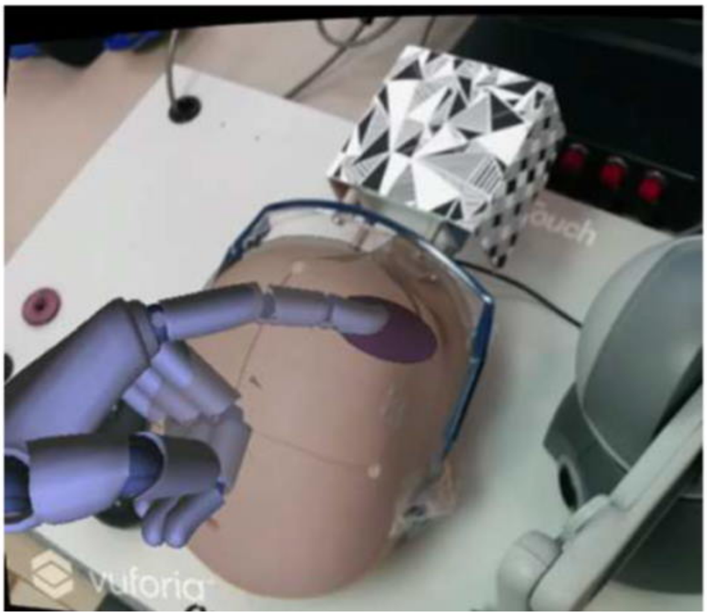

Figure 18. Virtual hand in the augmented environment

Figure 19. Process of targeting moving toward the anterior horn of a ventricle

CPR training

This AR application uses an AR HMD to provide real-time audio-visual feedback to the participants regarding the blood flow to the dependent organs as chest compressions are offered (figure 20) (Balian et al., 2019)

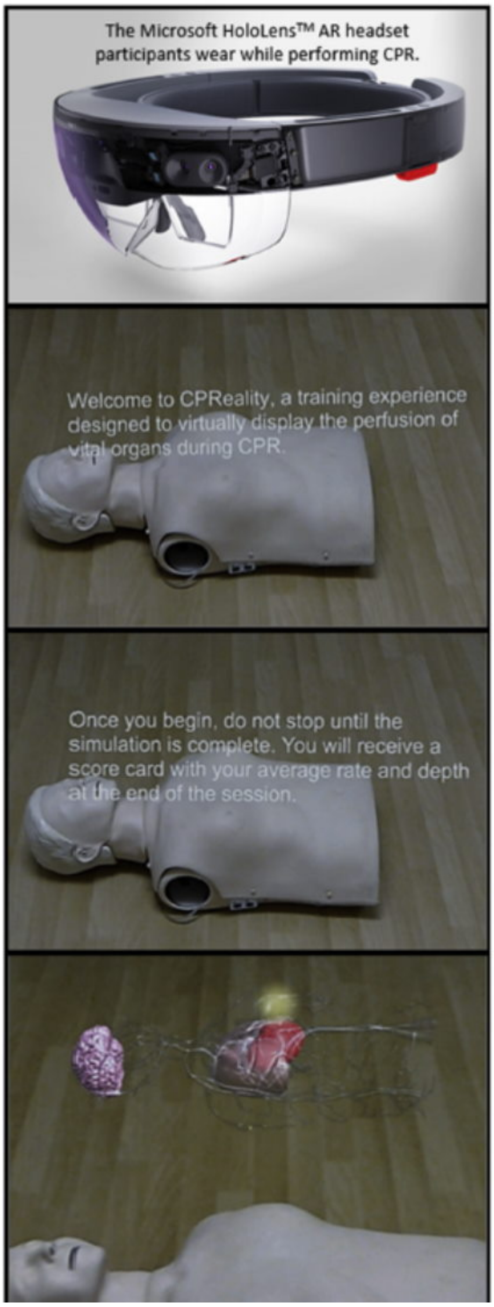

Figure 20. The AR CPR training application

2.6.2. AR AND ELECTROMAGNETISM

Electromagnetism as a discipline and concept is abstract and cognitively demanding; therefore, it is one of the most difficult subjects for students (Dori & Belcher, 2005). To understand abstract scientific concepts, students must build mental models to internalize and organize knowledge structures (Dede et al., 1999). Unlike other conceptual areas of physics, when it comes to electromagnetism, students' mental models must include abstractions and invisible factors that students do not refer in real life (Maloney et al., 2001). Dori et al. (2007) have pointed out the relevance of presenting the learning material not only in words, but also in visualizations to fully understand the nature of scientific phenomena and processes. In this sense, augmented reality has been recognized as a technology with great potential for science learning (Bujak et al., 2013; Cheng & Tsai, 2012; Wu et al., 2013), because it offers new ways of learning such as visual interactions that could be useful to improve learning outcomes (Cheng and Tsai, 2012; Gilbert, 2005; Rapp, 2005). AR simulations and visualizations have been used successfully to improve spatial abilities in science and engineering (Dünser et al., 2006; Martín-Gutiérrez et al., 2010).

In conclusion, according to what was presented in this section, the studies conducted regarding the AR applications examine the effects of AR in the context of learning but without focusing on specific AR technological and learning affordances, even though there are studies that emphasize the need of research on the examination of those affordances (Dalgarno & Lee, 2010; Mikropoulos and Natsis, 2011).

2.7. AFFORDANCES

The term "affordance" comes from Gibson's (1977) theory. In Gibson's original ecological psychology study, affordances are defined as latent cues in environments, such surface, object, or potential place for action. For example, a strong horizontal surface, above the knee affords the possibility of sitting or becoming a seat. The possibility of this becoming a seat is latent, but it only exists in relation to potential actions. Gibson gives an example. ''Knee-high for a child is not the same as knee-high for an adult, so the affordance is relative to the size of the individual'' (p.128). Gibson's (1977, 1979) theory of affordances has been widely adopted as an analytical frame for various disciplines, focusing on network learning and knowledge production (Boyle & Cook, 2004; Connoll & Dyke, 2004; Gever, 1991; Jones, Dirkinck -Holmfeld, & Lindstrom, 2006).

The notion that affordances are not related to the environment or the individual, but to the relationship between the individual and their perception of the environment, and, importantly, that this relationship provides a direct link between perception and action is the main related issue discussed. Oliver says that the "essentialist position" of the direct relationship between perception and action that underpins Gibson's theory of universal and natural affordances makes the term "speculative rather than analytic" (2005, p. 403).

Norman (1988) introduced the difference between the actual (physical) and perceived (cognitive) characteristics of things. Norman's view of actual affordances agrees with Gibson's (1977) concept of original notion for natural vision, where human and animal actors can directly perceive affordances in the environment.

Norman's (1988) introduction to perceive affordances helps in some way to solve how and what an object can afford an actor through the opportunity to select and manipulate the object. However, distinguishing the real (physical) from the perceived (cognitive) affordances is still an issue. Norman's technological affordances go beyond the ability of users to see, select, or act on them, and therefore beyond the ability of researchers to study them, they remain in the realm of the designers. Due to this ongoing dilemma embedded in the definitions of Gibson (1977), Gibson (1979) Norman (1988), and Oliver (2005) propose the term to be removed. Concerns over the different definitions of technical affordances made Norman (2008) to replace the term with signifiers. However, other theorists are participating is studies to redefine the concept of affordances in an effort to maintain its analytical usefulness.

2.7.1. LEARNING AFFORDANCES

Kirschner (2002), introduced the term educational affordances as a characteristic of artifacts, which decide how and whether a specific learning behavior can be implemented in a particular situation. The researchers used the word pedagogical affordances in the same way to describe prevailing opportunities for knowledge building (Dickey, 2003).

The research Dickey (2003), talked about the capacity of the synchronous discourse tools offering opportunities for direct association and change, as well as the possibilities in favor of manipulation and investigation to help the knowledge building. The terms pedagogical affordances and educational affordances were well utilized by Hollins and Robbins (2008), while talking about identity, activity, community, space, and equipment. Dalgarno and Lee (2010) introduced the term learning affordances in a study to explain the activities and tasks that learners can use in a Virtual Learning Environment (VLE) that are advantageous for learning. They state that learning ability is the consequence of VLE utilized to assist learning tasks that result in inducing the growth of higher-level information and knowledge that is spatial that are impractical or impossible into the real world, and increase intrinsic motivations and engagement. In another study, researchers examined the opinions of teachers about learning affordances. The study recommends the affordances of movement, awareness and co-presence, psychological connections, projection of role, artificial 3D experiences, and authentic 3D experiences (Gamage et al., 2011). Warburton (2009) in his study refers to the affordances for education rather than determining it as educational or learning. According to Warburton (2009), affordances for training include enhancing interactions, contextualization and visualization, the experience of real culture and content, immersion, identity play, simulation, creation of content and community presence.

2.7.2. Technological affordances

Learning affordances do not mean an already defined functionality. Photography, recording, typing, or editing can't be considered learning affordances (All of these can be considered affordances of tools). Although, they are the enablers of affordances which include idea-sharing and interaction (Mcloughlin & Lee, 2007). Based on this, we can say that it is a grouping of "creativity and imagination of an individual user as they conceptualize issues or problems in their own environment that the specific tool might help or facilitate to resolve" (Burden & Atkinson, 2008, p. 122). A whiteboard has technological affordances (that can be drawn and written), but this transforms into learning affordances when it is employed for other pedagogical purposes (instructors can invite their learners to use it; or a group of instructors, trainees, or students may use it for a brainstorming or discussion), where "it becomes a point of discussion and the construction/negotiation of meaning occurs around it" (Mishra & Koehler, 2007, p. 2220).

About the concept of technological affordances, the interaction practices are not determined by the technology, rather these are determined on the basis of how an actor utilizes the use of technology. Affordances are not static types of technology; rather these are the features that may be perceived by users. Hence, an affordance occurs when a user perceives it and also perceives the possible actions related to it. Hutchby (2001) in his study drew on the perception of affordances whilst analysing the technological interaction. Gibson and Norman argued in their study that the types of technology can restrain and afford the interactional perspective (Hutchby, 2001), but that utilizing the concept of affordances allows us to move away from both technological social constructionism and determinism in the analysis of technological interaction. Thus, the perception of affordances permits technological interaction analysis, which validates how the interaction shifts to specific technological features.

2.7.3. AR AFFORDANCES

As an enhanced version of the real world, Augmented Reality (AR) has great potential to be used for educational purposes; its affordances and potential can be further extended when an Augmented Reality (AR) system is considered by combining several technologies. The study Wu et al. (2013), identified the affordances and features of Augmented Reality (AR) systems in five characteristics on the basis of research which uses Augmented Reality (AR) for educational purposes. The study suggests that Augmented Reality (AR) can enable (1) ubiquitous, collaborative and situated learning,

(2) learning content in 3D perspective, (3) bridging the gap between formal and informal learning, (4) visualizing the invisible, and (5) learners' senses of presence, proximity, and immersion. Each of the aforementioned aspects will be discussed in this section.

First of all, AR can improve the learning experience with the help of 3D digital objects, which can be helpful for students in terms of interaction. AR allows learners to utilize the 3D digital objects for enhancing visual awareness of the target environment or system (Arvanitis et al., 2007). The students may inspect the 3D object from assorted perceptions to improve their level of understanding (Chen et al. 2011). Kerawalla et al. (2006), presented an example of the usage of 3D Augmented Reality (AR) in instructing astronomy. The study comprised of two sessions i.e., Augmented Reality and conventional teaching. In the AR session, teachers as well as students used a mixture of technologies which include web camera, projector, Augmented Reality tile, virtual 3D modeling package, and whiteboard for observing and moving a virtual 3D revolving earth for the purpose of learning about the earth, Sun, and day and night. The conventional teaching involves printed book reading, a demonstration of the usage of 3D physical objects, and a lecture on the solar system (which includes a string, a tennis ball, and a torch) for learning the same topics. The researchers evaluated the queries of teachers in both sessions and interviews of the teachers after the sessions. It was revealed that the teachers recognized the advantages of the usage of 3D imagery and understood that AR can make unreachable subject matter accessible to students. Though, Kerawalla et al. (2006), did not associate the 3D learning experience created by AR and the management of the real-world 3D physical models for the students. Initial research on the education of chemistry can provide some significant information about this question. Prior research proved that students who were comfortable with both, computer and physical models outperformed the students who were comfortable with any one of the models (Copolo and Hounshell, 1995). Wu, Krajcik, and Soloway (2001) argued that both computer-based and physical learning models "should be provided through class instructions because different students have preferences for different types of models and symbol systems" (p. 838). However, there is a lack of evidence to support the argument that AR-based 3D virtual models are better than real-world 3D models.

The second characteristic of affordances support the application of handheld digital devices in Augmented Reality (AR). Broll et al., (2008) and Dunleavy et al., (2009) suggested the usage of hand-held digital devices, location registered technology, wireless connection, and the ubiquitous or the mobile-AR system can empower pervasive, collaborative and situated learning augmented by computer simulations, games, and virtual objects in real environments. The affordances of this type of system might include context sensitivity, connectivity, portability, individuality, and social interactivity (Klopfer, 2008; Squire & Jan, 2007; Squire & Klopfer, 2007). For instance, diverse mobile-AR games i.e., Mad City Mystery (Squire & Jan, 2007) and Environmental Detectives (Klopfer, 2008; Squire & Klopfer, 2007) was developed for supporting virtual learning. The students in Environmental Detectives used handheld computers for analysis, data gathering (unique to the location), evaluation and interpretation of the data, and recommended context-sensitive solutions. The researchers proved that making students play virtual games in real-world can play a vital role in enhancing the context-sensitivity of the students, and results in more informed decision making (Squire and Klopfer, 2007).

Furthermore, Nagata (2003), suggests that the application of handheld digital devices in the digital environment may result in distraction during learning and might increase task interruptions. An AR system has the ability to detect the location of students, their work status, can provide task reminders, and can offer alternatives that can help students in refocusing on assigned tasks. These attention-conscious characteristics may be helpful in decreasing task interruptions and managing the attention of students (Roda & Thomas, 2006). Apart from that, social communication can be enhanced, when students collaborate through networked mobile devices as well as face-to-face interactions.

Birchfield & Megowan-Romanowicz, (2009) showed that different investigation methods can also be provided to encourage individuality (Klopfer, 2008).

Bronack (2011), suggested that AR along with other immersive methods i.e., virtual worlds and serious games offer affordances of presence, immersion, and proximity. AR may provide an arbitrated space that injects a sense of being in a place with others in learners. Such a sense of presence can increase recognition of the learners' community in students (Squire & Jan, 2007). Apart from that, the AR system might comprise real-time feedback and may provide verbal and nonverbal indications for fostering the sense of immediacy in students (Kotranza et al., 2009). Immediacy is significant for fostering the affective learning side, virtual objects, the AR brings together learners, and characters in the real world can enhance immediacy. Finally, immersive media (such as AR) can offer immersion to learners, which is "the subjective impression that one is participating in a comprehensive, realistic experience" (Dede, 2009, p. 66). Dede (2009), suggested that immersion can make learning (in physical environments) possible.

Arvanitis et al., (2007) and Dunleavy et al., (2009), suggested that AR covered virtual objects or environment-enabled visualization of invisible concepts or information about physical objects or events is also a characteristic of affordances. AR systems can be helpful for learners in visualizing abstract science concepts or unobservable phenomena i.e., magnetic fields or airflow by using virtual objects, which include vectors, symbols, and molecules. For instance, Augmented Chemistry permits learners to choose chemical elements, combine them into 3D molecular models, and exchange the models (Clark, Dünser, and Grasset 2011; Fjeld & Voegtli, 2002) improved a paper-based coloring book containing 3D content and gave a pop-up book experience of visualizing the content of book to children. These improved real world objects generate new visualizations having capability to improve the understanding of visible and hidden concepts or phenomena in students.

The fifth characteristic of affordances acknowledged by researchers is that AR has the ability to bridge the gap between formal and informal learning. For instance, the CONNECT project used AR and other technologies for creating a virtual science thematic park environment (Sotiriou & Bogner, 2008). The modes of the environment are twofold: 1. museum mode and 2. school mode. The environment includes both virtual and real-world scenarios i.e., conventional field trips to science museums, pre and post visit curricular activities, and experiment and modeling activities. In this project, science learning at school was associated with learning experiences of the virtual and conventional museum visits, with the help of AR. It was indicated in the early stage assessment of the CONNECT project that the environment has positive effects on the intrinsic motivation of students for learning science and understanding the concept of friction theory (Sotiriou & Bogner, 2008).

According to Cheng & Tsai (2012), science learning offered by image-based AR has three main aspects, which include spatial ability (Kerawalla et al., 2006; Martın-Gutierrez et al., 2010; Núñez et al., 2008; Shelton and Stevens, 2004), applied expertise in the laboratory (Andujar et al. 2011; Eursch, 2007), and conceptual understanding (Koong Lin et al. 2011). Image-based AR technology is focused on the demonstration of three-dimensional space, its affordances for science learning are primarily related to spatial ability and extended to practical skills or conceptual understanding. On the contrary, the usage of location-based AR is expected to help collective inquiry-based activities in science learning (Dunleavy et al. 2009; Rosenbaum et al. 2007; Squire and Jan 2007; Squire & Klopfer, 2007; O'Shea et al. 2011). Spatial AR technology is considered as position-free and developed within the physical environment. Hence, it offers more opportunities to design activities to learners for investigating scientific topics.

The study by Dunleavy, Dede & Mitchell (2008), proved that high engagement of students and teachers in the AR application is attributed to the unique affordances of the AR simulation. The study suggested that unique affordances of AR include greater conformity with real-world environment, team members can communicate face-to-face with its bandwidth on multiple dimensions, and the capability to promote kinesthetic learning via physical movement through richly sensory spatial environments.

2.7.4. VR AFFORDANCES

The Six learning affordances generated by the affordances of Virtual Reality (VR) and the Multi-user Virtual Environments (MUVEs) include (Mantziou, Papachristos & Mikropoulos, 2018):

I. Free navigation

II. Modeling and Simulation

III. Creation

IV. Content delivery and/or presentation

V. Cooperation and Collaboration

VI. Multichannel communication

Basically, the learning affordance of the free navigation is originated from the first-order experiences, affordances of 3D spatial representations, and first-person user point of view. Free navigation can be defined as the activities like meaningful virtual field tours and trips, also the gameplay such as scavenger hunts.

The learning affordance of modeling and simulation enlarges from the majority of the affordances, specifically from transduction and reification, size, and it also includes visualization. The actions discussing modeling consist of interpretation and data presentation, whereas visualization and simulation keep on modeling and are related to the real system reproduction, a virtual experiment and the simulation of a natural phenomenon. Game development and the design of the environment are some of the modeling and simulation activities.

Creation is originated from the natural semantics, multisensory intuitive and real-time interaction. The scripting and building are part of creation and they can be defined as the actions like constructing a virtual building, design of a virtual learning environment, designing course content, and code writing for the conduct of a virtual object.

Content delivery and presentation are originated from all affordances, specifically from the shared interactive whiteboards and SLOODLE. Content delivery and presentation is related to the activities such as exhibitions and presentations.

The learning affordance of cooperation and collaboration rises from all the affordances and gets improved by the manifestation of a contestant. The support and teamwork are similar to the social interaction, meetings, and role-play.

The multichannel communication is originated from the affordances of real-time communication, multisensory intuition and the users by avatar representation.

Communication is similar to the activities such as conferences, discussions, lectures, and chatting.

Regarding the technological affordances of VR, they are the following (Mikropoulos & Natsis, 2011):

- Multisensory channels.
- Immersion.
- Presence.
- Autonomy.
- Natural semantics.
- User's representation through avatars.

Multisensory channels, Autonomy and Natural semantics are considered to characterize AR as well. As far as the rest three are concerned, there is a total immersion in VR, whereas partial immersion in AR, presence is regarding a total virtual environment in VR, whereas an enriched physical environment in AR and finally "user's representation through avatars" regarding VR will be considered to be "Physical representation of the user in the real environment" as far as AR is concerned.

According to the above, the differences between the technological affordances of AR in comparison with VR are summarized as following (Craig, 2013; Mikropoulos & Natsis, 2011):

1. In AR the physical world is augmented by digital information superimposed on a view of the physical world, whereas in VR there is a virtual environment.
2. In AR, the information is displayed in registration with the physical world, whereas in VR the information is displayed in a virtual environment.
3. The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world, whereas in VR the information is displayed in a virtual world.
4. In AR, immersion is spatial, whereas in VR is total.
5. In AR, presence refers to an enriched physical environment, whereas in VR, in a total virtual environment.
6. In AR, there is a physical representation of the user in the real environment, whereas in VR user's representation is through avatars.

2.8. TECHNOLOGY ACCEPTANCE MODEL (TAM)

Technology evolved rapidly during the past two decades. It revolutionized almost every aspect of life. Especially it changed the conventional education system. Virtual Reality and Augmented Reality played a significant role in the advancement of learning through technology. Over the past 20 years, people around the globe moved into a new era of exceptional digital interference in such a way that major technological innovations and advancements in technology have been adopted (Crosbie, 2008). A substantial amount of effort was made in developed countries as well as underdeveloped countries to promote and encourage the adoption of the latest technology. In regard of this, various theoretical models have been proposed by different researchers, which help in examining and predicting the behavior of users towards the adoption and usage of Technology. Some of the famous models include Theory of Planned behavior (TPB), Theory of Reasoned Action (TRA), and the Technology Acceptance Model (TAM). The focus of this study is on Technology Acceptance Model (TAM). It was proposed by Fred D. Davis in the extension of Theory of Reasoned Action (TRA) (Davis, Bagozzi, & Warshaw, 1989). This theory explains the process of how the users adopt and accept a new technology system. TAM comprise of different components that include Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude Toward Using (ATU), Actual Use of System (AUS), and Behavioral Intention to Use (BIU). TAM describes the association among different components as follow:

- ATU has a direct effect on BIU, which subsequently determines AUS
- PEOU and PU have a direct effect on ATU
- PEOU has an impact on PU

2.8.1. Technology Acceptance Model (TAM) and its different versions

The theory of Technology Acceptance Model (TAM) was introduced by Fred D. Davis in the year 1989. It was used to evaluate and validate how quickly and easily a user can perceive the use of technology and how important and useful the technology is for its users. The original version TAM-1 comprises six variables, as shown in figure 21.

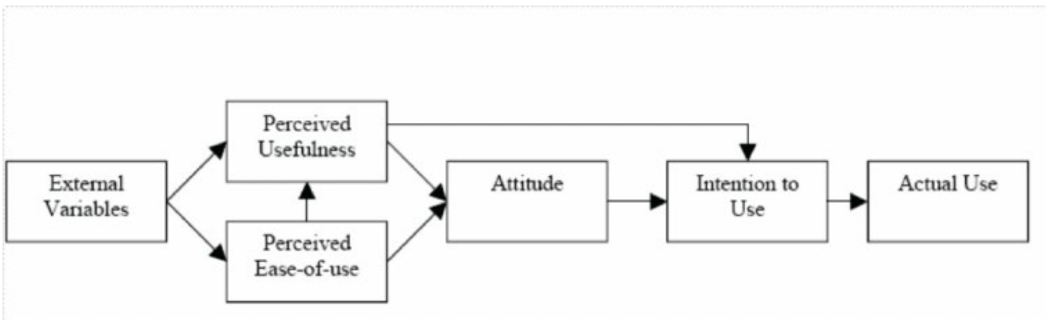

Figure 21. Technology Acceptance Model Version 1 (TAM-1)

TAM-1 involves six variables which include External Variables (EV), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude towards Using (ATU), Behavioral Intention to Use (BITU), and Actual System Use (ASU).

With the advancement of technology, Venkatesh & Davis (1996), further extended the TAM-1 and introduced TAM-2. The researchers introduced some new factors in the variable "Perceived of Usefulness". Figure 22 shows the TAM-2 framework.

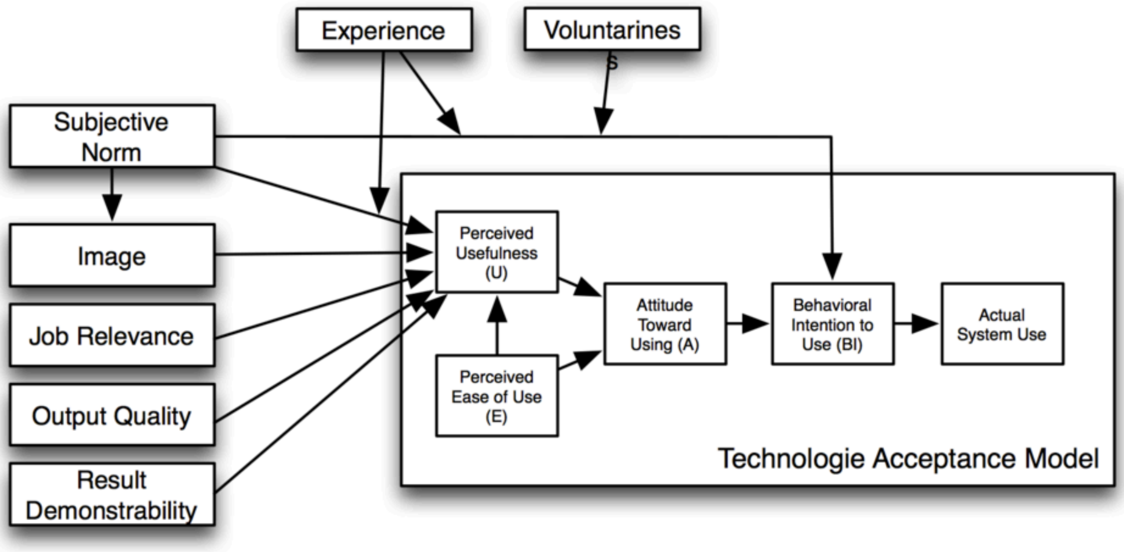

Figure 22. Technology Acceptance Model Version 2 (TAM-2)

Later, in the year 2018, both TAM-1 and TAM-2 were upgraded by Linda Shore. The upgraded version was named as Unified Theory of Acceptance and Use of Technology (UTAUT). This theory seems to be more effective in understanding the intention of user towards the usage of VR systems as well as later behavior towards the usage of technology (Shore et al., 2018). In this model, the number of influencing factors such as 'Job Relevance' were removed. The main reason behind this is that it is considered to be a duplicate factor of 'Social Influence' which was present in previous versions. Figure 23 shows the UTAUT framework.

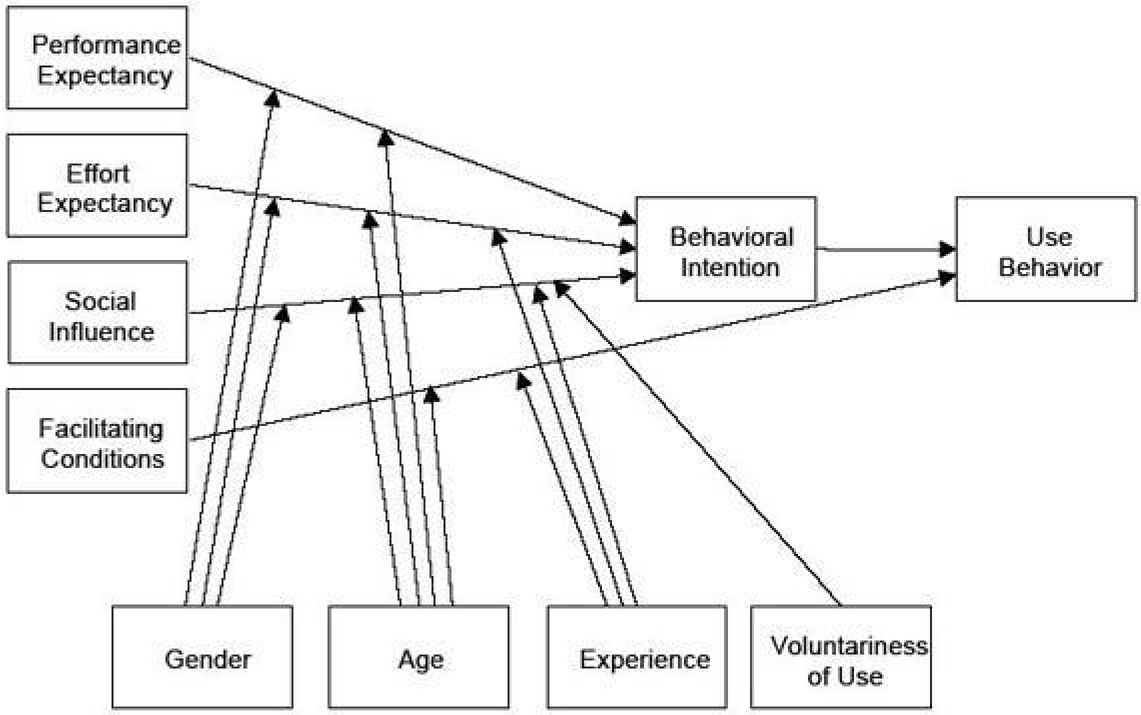

Figure 23. Unified Theory of Acceptance and Use of Technology (UTAUT)

After continuous efforts and significant research on TAM-1 and TAM-2, Venkatesh and Bala (2008) combined the existing TAMs and proposed a new model, the "Technology Acceptance Model version 3" (TAM-3). The proposed model states that Perceived Ease of Use and Perceived Usefulness have four factors i.e., system characteristics, individual differences, facilitating conditions, and social influence. Figure 24 shows the TAM-3 framework.

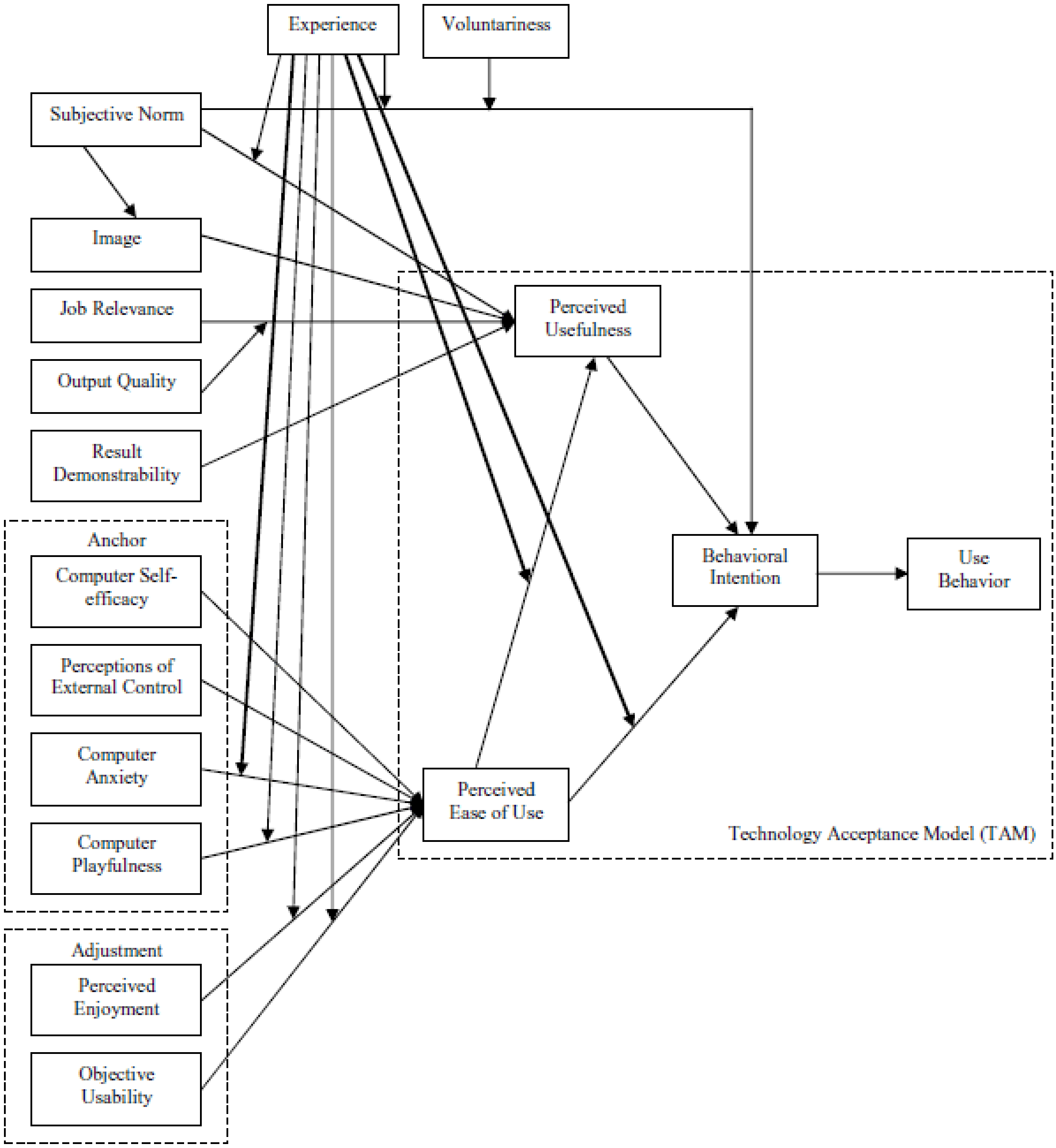

Figure 24. Technology Acceptance Model Version 3 (TAM-3)

Unified Theory of Acceptance and Use of Technology (UTAUT) is the one of the most widely used models for evaluation of the acceptance for different technologies in various fields. Mahalil, Yusof, & Ibrahim (2020) used UTAU) to evaluate users' acceptance of Virtual Reality-based exercises. Apart from that, they identified some impactful factors that influence the acceptance of VR technology in athletics. A large number of researchers applied TAM in education sector. Hidayah et al. (2020) evaluated the acceptance of Android-based Academic Information System (AIS) among students of Universitas Islam Negeri (UIN) Syarif Hidayatullah, Jakarta. The researchers applied TAM on a sample size of 237 students and used SmartPLS version 3.0. Thongkoo, Daungcharone & Thanyaphongphat (2020) used TAM to investigate the acceptance of distance learning among the students studying HTML, CSS, function and control statement of PHP.

An increase in interest in the application of Augmented Reality (AR) in different learning environments has been noticed. According to Ibáñez & Delgado (2018), the Augmented Reality (AR) promotes positive learning environments. In addition to the usage of AR technology, a large number of organizations are focusing on the implementation of mobile AR technology for educational purposes. With an increase in usage of smartphone and other digital devices such as tablets and laptops etc., a large number of institutes are willing to implement such applications and tools in their learning systems (Gosku, 2021). There is a great significance of the role of teachers in incorporating new digital technology. Every new technology and innovation demand the modification in the attitude and beliefs of teachers (Fullan, 2015). In this regard, various researchers have proposed different models and theories from the perspective of social psychology to investigate the elements that influence the teachers to adopt AR mobile technology in teaching.

In augmented reality, User Experience (UX) is important, but is often ignored by non-professional developers of AR applications. So far, there is no such criteria exists to measure the User Experience (UX) for AR application users. According to Arifin, Sastria, and Barlian (2018), the Standard Metrics is the tool that can determine the quality of User Experience (UX) in AR applications. This can also help in improving the UX in AR applications, especially in education sector. Another study has been conducted to develop and validate the Augmented Reality Immersion (ARI) questionnaire in order to measure the immersion of Augmented Reality (AR) location-aware applications. The researchers used the hierarchical model of immersion to develop a well-structured questionnaire with validity and reliability so that an ARI questionnaire could portray an immersion when utilizing a location-aware ARI application for learning and entertainment. The findings indicate that the ARI questionnaire is a significant and favorable instrument for immersion measurement in the perspective of location-aware Augmented Reality (AR) applications for entertainment and learning (Georgiou & Kyza, 2017).

Jang et al. (2021), discussed the application of AR and VR in teaching and learning. The researchers used an extended Technology Acceptance Model (e-TAM) to examine the influence of Social Norms (SN), Technological Pedagogical and Content Knowledge (TPACK), and Motivational Support (MS) on the Intention of teachers for using technologies in teaching. They designed a questionnaire and received responses from a sample of 292 Korean school teachers using an online survey. The results showed that TPACK has a significant impact on Perceived Usefulness and Perceived Ease of Use. This means that teachers who understood AR and VR applications were aware of the usefulness and ease of use of them. SN seemed to have a significant impact on Perceived Usefulness. Apart from that, MS had a great influence on Perceived Ease of Use. Another study used Technology Acceptance Model (TAM) and Modified Unified Theory of Acceptance and Use of Technology (UTAUT2) to identify the features having an impact on the technology adoption model in digital painting on hand-held digital devices among students. The researchers surveyed 209 students of media arts at King Mongkut's University of Technology Thonburi (Bangkhuntien), Thailand. Results showed that Perceived Ease of Use had a great influence on technical expectancy and social influence did not affect the usage of tablet devices in art creation (Kangwansil & Leelasantitham, 2020).

2.8.2. Mobile Augmented Reality Acceptance Model (MARAM)

Koutromanos & Mikropoulos (2021) introduced the Mobile Augmented Reality Acceptance Model (MARAM), in which the researchers added some variables to the Technology Acceptance Model (TAM). These variables include perceived enjoyment, perceived relative advantage, mobile self-efficiency, and facilitating conditions. These variables help in finding out the elements that influence the intention of teacher to use AR application in their teaching methodology. Figure 25 shows the MARAM framework.

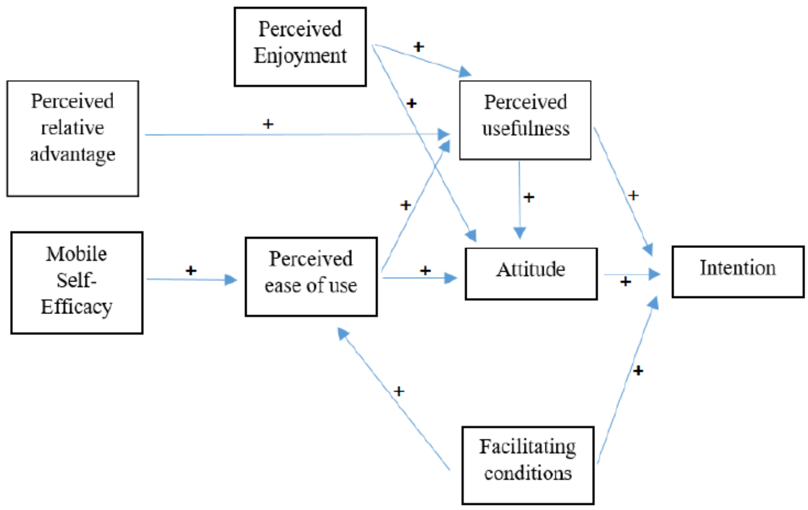

Figure 25. Mobile Augmented Reality Acceptance (MARAM) Framework

The researchers applied MARAM on a sample size of 127 teachers who developed their own AR application and were using mobile AR applications for academic purposes. The proposed model comprised of eight variables. Results showed that perceived usefulness, attitude, and facilitating conditions explained 48.1% of the variance in the intention of the teachers to use mobile bases AR applications in their teaching. Perceived ease of use, perceived usefulness, and perceived enjoyment explained 49.2% of the variance in attitude of the teachers to use mobile bases AR applications in their teaching. Perceived ease of use, perceived relative enjoyment, and perceived enjoyment explained 44.5% of the variance in perception of usefulness in teachers to use mobile bases AR applications in their teaching. Facilitating conditions and mobile self-efficacy explained 52.8% of the variance in perception of ease of use in teachers to use mobile bases AR applications in their teaching. In addition, mobile self-efficacy had substantial impact on perceived ease of use, which means that teachers who are comfortable with using hand-held digital devices can effectively use mobile-based AR applications in their teaching.

2.8.3. Technological Affordances Measures

The six differences between AR and VR technological affordances have been presented in section 2.7.4. Regarding immersion, the effects induced by immersion have been proposed to be examined through a Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993). As far as the presence is concerned, the Temple Presence Inventory (TPI) questionnaire has been proposed and widely used for measuring the presence in virtual and augmented reality (Lombart, Bolmarcich, & Weinstein, 2009; Vrellis et al., 2020). About the rest four technological affordances that are met in AR (1. The physical world is augmented by digital information superimposed on a view of the physical world, 2. the information is displayed in registration with the physical world, 3. the information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world, 4. there is a physical representation of the user in the real environment), these have been examined in several studies through the assessment of learning activities (Mantziou, Papachristos, & Mikropoulos, 2018). However, as presented above, TAM has been used in several domains and is the state-of-the-art model for the evaluation of the technology acceptance which obviously arises from the technological affordances.

Several studies have related the technological affordances with the TAM questionnaire. Dalgarno & Lee (2010) argue that the technological affordance of immersion enhances the Perceived Usefulness of VR. In line with this, Makransky &

Peterson (2019) argue that when interaction is coupled with immersion it has a significant influence on Perceived Usability. Lee et al. (2010) also presented similar findings and Makransky & Lilleholt (2018) reported that increased immersion can lead to higher level of interaction and thus higher Perceived Usefulness and Perceived Ease of Use.

For this study, a TAM questionnaire will be used to examine those four AR technological affordances mentioned above. More specifically, the MARAM questionnaire (Koutromanos & Mikropoulos, 2021) will be used, as it was developed in order to examine the technology acceptance of AR applications for education. The variables of the other versions of TAM that have been added to the initial TAM focus on the use of information technology applications or social influence which are not suitable for the purpose of the current study which is learning. The variables that have been added to the MARAM questionnaire compared to the initial TAM, namely Perceived Relative Advantage, Facilitating Conditions, Perceived Enjoyment and Mobile Self-Efficacy are factors that support the examination of the AR technology acceptance for education as Perceived Relative Advantage compares the AR technology for teaching with other technologies, Facilitating Conditions refer to the resources, knowledge and time that is needed to use AR applications in teaching, Perceived Enjoyment examines users enjoyment during the use of AR applications and Mobile Self-Efficacy refers to the use of mobile devices in the context of AR applications. In addition, the MARAM questionnaire has showed that the Intention to use mobile AR applications can be explained by 48.1% by other variables, which is a very high percentage (Koutromanos & Mikropoulos, 2021). In conclusion, the MARAM questionnaire (Koutromanos & Mikropoulos, 2021) will be used in the context of the current study as it is designed to be used for AR applications for education, its variables are suitable to examine technology acceptance of AR for education and the Intention to use AR applications for education has showed that can be explained by a very high percentage by other variables of the questionnaire.

To sum up, a TAM questionnaire, a SSQ and a TPI questionnaire will be used to examine the effects of the AR technological affordances on the acceptance of AR technology for learning purposes, by designing an AR application based on the AR technological affordances and comparing it with a similar VR application. By comparing an AR application with a similar VR application, namely by studying the technology acceptance, the sense of presence and the simulator sickness, it is considered that the different technological affordances between AR and VR mentioned in section 2.7.4 are examined

CHAPTER III: METHODOLOGY

3.1. INTRODUCTION

The aim of the study was to examine the effects of the AR technological affordances on the acceptance of AR technology for educational purposes.

Two similar, in terms of affordances, technological environments were chosen, AR and VR in order to compare the effects of each technology.

Given that the differences in the technological affordances of AR and VR are those six mentioned in section 2.7.4, we aimed, by comparing the effects of each technology on the acceptance of the corresponding technology as well as the sense of presence and the simulator sickness to examine the effects of those particular six affordances.

In this context, the empirical study consisted of four parts. An experiment with an AR application, a completion of a relevant questionnaire, an experiment equal to that with a VR application which simulated the physical environment of the AR application and the completion of the same questionnaire as before (adjusted for the VR experience).

A quantitative data analysis was conducted to examine the effects of the AR and VR applications on students' technology acceptance by applying descriptive statistics, examining the relationship between the variables of the AR questionnaire, examining the relationship between the variables of the VR questionnaire and comparing the variables of the AR and VR questionnaires and also regarding the sense of presence as well as the simulator sickness.

3.2. RESEARCH QUESTIONS

In order to fulfil the aim of the study, the following research questions were formed:

1. What is the user's technology acceptance of AR in terms of:

a. Intention to use AR applications?

b. Attitude towards AR applications?

c. Perceived ease of use regarding AR applications

d. Perceived usefulness regarding AR applications?

e. Perceived relative advantage regarding AR applications?

f. Facilitating conditions regarding AR applications?

g. Perceived enjoyment regarding AR applications?

h. Mobile Self Efficacy regarding AR applications?

The following hypotheses are considered:

H1a. Perceived ease of use (PEOU) has a positive effect on perceived usefulness (PU).

H1b. Perceived ease of use (PEOU) has a positive effect on attitude (Att).

H2a. Perceived usefulness (PU) has a positive effect on intention (I).

H2b. Perceived usefulness (PU) has a positive effect on attitude (Att).

H3a. Perceived enjoyment (PE) has a positive effect on attitude (Att).

H3b. Perceived enjoyment (PE) has a positive effect on perceived usefulness (PU).

H4. Attitude (Att) has a positive effect on intention (I).

H5a. Facilitating conditions (FC) has a positive effect on intention (I).

H5b. Facilitating conditions (FC) have a positive effect on perceived ease of use (PEOU).

H6. Perceived relative advantage (PRA) has a positive effect on perceived usefulness (PU).

2. What is the user's technology acceptance of VR in terms of:

    a. Intention to use VR applications?

    b. Attitude towards VR applications?

    c. Perceived ease of use regarding VR applications

    d. Perceived usefulness regarding VR applications?

e. Perceived relative advantage regarding VR applications?

f. Facilitating conditions regarding VR applications?

g. Perceived enjoyment regarding VR applications?

h. Mobile Self Efficacy regarding VR applications?

The following hypotheses are considered:

H1a. Perceived ease of use (PEOU) has a positive effect on perceived usefulness (PU).

H1b. Perceived ease of use (PEOU) has a positive effect on attitude (Att).

H2a. Perceived usefulness (PU) has a positive effect on intention (I).

H2b. Perceived usefulness (PU) has a positive effect on attitude (Att).

H3a. Perceived enjoyment (PE) has a positive effect on attitude (Att).

H3b. Perceived enjoyment (PE) has a positive effect on perceived usefulness (PU).

H4. Attitude (Att) has a positive effect on intention (I).

H5a. Facilitating conditions (FC) has a positive effect on intention (I).

H5b. Facilitating conditions (FC) have a positive effect on perceived ease of use (PEOU).

H6. Perceived relative advantage (PRA) has a positive effect on perceived usefulness (PU).

3. What is the relationship between technology acceptance for AR and VR?
4. What is the user's sense of presence in AR?
5. What is the user's sense of presence in VR?
6. What is the relationship between user's sense of spatial presence in AR and VR?
7. What is the user's simulator sickness in AR?
8. What is the user's simulator sickness in VR?
9. What is the relationship between user's simulator sickness in AR and VR?

3.3. PARTICIPANTS

A total of 47 undergraduate students of the Department of Primary Education, University of Ioannina, Greece participated in this study. Their participation was voluntary. All the students were in the last semester of their studies. During the experimental procedure, the students had just completed the course "Project Development with Emerging Learning Technologies". In the context of this course the development of mobile AR applications was included.

All the students participated in the survey. Out of 47, 39 (83%) participants were females and 8 (17%) participants were males (Table 3).

Table 3. Gender Distribution of the participants

Gender		Frequency	Percent (%)
Valid	Female	39	83.0
	Male	8	17.0
	Total	47	100.0

Table 4. Descriptive Statistics for the age of the participants

Age		
N	Valid	47
	Missing	0
Mean		24.06
Std. Deviation		6.495
Minimum		21
Maximum		53

Table 5. Age Distribution of the participants

Age		Frequency	Percent (%)
Valid	21	10	21.3
	22	24	51.1
	23	4	8.5
	24	2	4.3

	25	1	2.1
	26	1	2.1
	28	1	2.1
	36	1	2.1
	37	1	2.1
	48	1	2.1
	53	1	2.1
	Total	47	100.0

The average age of the participants was 24.06 (table 4). The standard deviation of participants' age was 6.495. The youngest survey participant was 21 years old whereas the eldest was 53 years old (Table 5). Most of the participants were 22 years old (or we can say under 25 years of age).

Regarding their experience, the participants reported above mid-range score in computer experience and approximately mid-range score for video games, virtual reality, and augmented reality (table 6).

Table 6. Descriptive statistics of participants' experience (N = 47)

	Mean	Std. Deviation
Computer experience	3.64	.673
Video games experience	2.60	1.155
Virtual Reality Technologies experience	2.36	.987
Augmented Reality Technologies experience	2.51	.906

Scale: 1=None, 5=Very much

3.4. Research Procedure

3.4.1. Formation and description of the educational material

The design of the educational material was based on the technological affordances of AR and VR as they are described in the previous chapter. More specifically, the educational material was created driven by and in order to meet the following technological affordances:

1. In AR the physical world is augmented by digital information superimposed on a view of the physical world, whereas in VR there is a virtual environment.
2. In AR, the information is displayed in registration with the physical world, whereas in VR the information is displayed in a virtual environment.
3. The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world, whereas in VR the information is displayed in a virtual world.
4. In AR, immersion is spatial, whereas in VR is total.
5. In AR, presence refers to an enriched physical environment, whereas in VR, in a total virtual environment.
6. In AR, there is a physical representation of the user in the real environment, whereas in VR user's representation is through avatars.

3.4.2. AR Application design

For the development of the AR application, Unity 3D and C# were used.

3.4.3. AR APPLICATION – ELECTROMAGNETIC FIELDS

This application was created to visualize electromagnetic fields emitted by various everyday devices. A cell phone, DECT phone, laptop and a router were placed in specific locations of the physical environment (figure 26).

Figure 26. Physical environment of the AR application

By wearing the Magic Leap 1 glasses and pointing each of the digital objects by the remote control of the Magic Leap 1, the participants could "turn on/off" the devices and enable/disable the corresponding wave visualization of each device. When users pointed the controller to the devices the pointer line was changed from red to green. The electromagnetic waves were visualized as a set of concentric spheres centered on each device and expanding in all directions (figures 27-32).

Figure 27. User pointing the remote controller to the laptop in the AR application(left). Remote control line is red when user does not point a device (right)

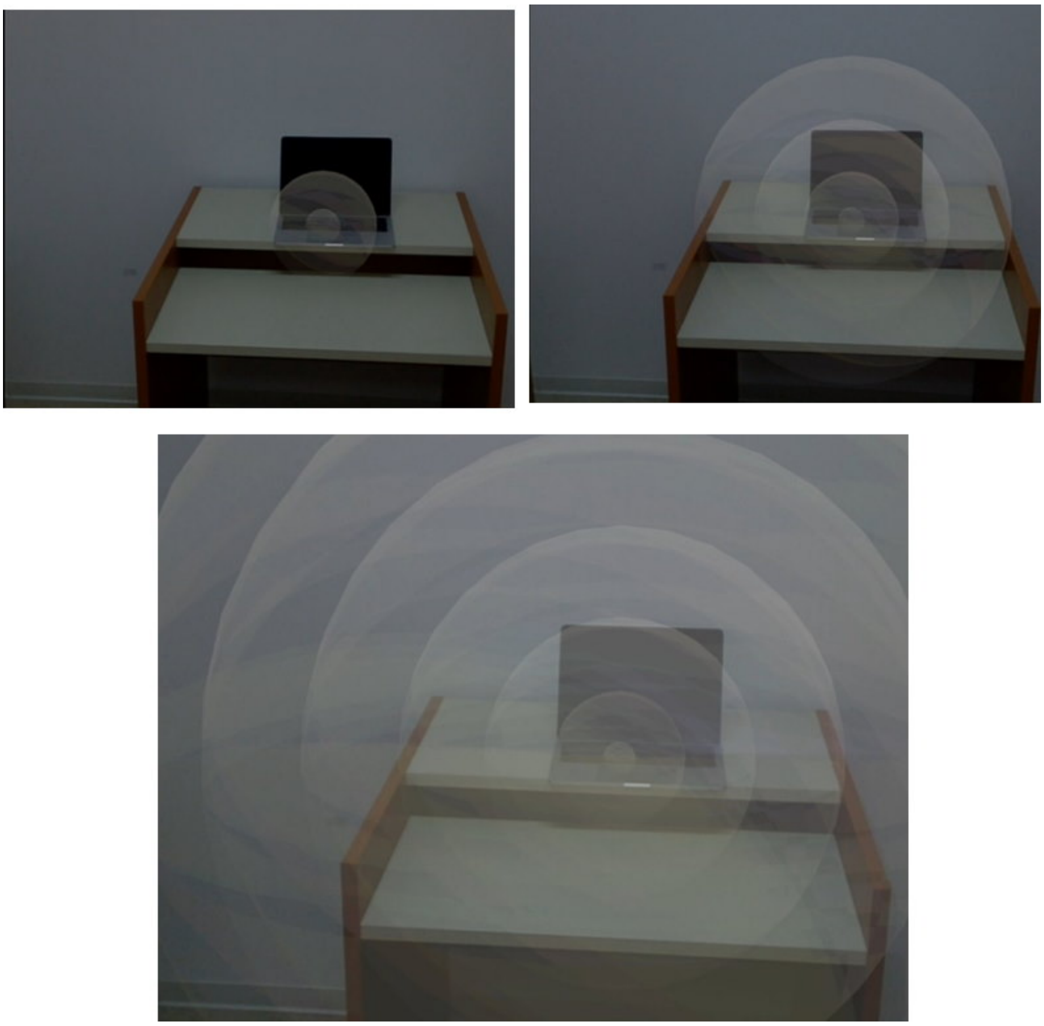

Figure 28. Electromagnetic waves expanding from laptop as virtual objects in the physical environment of the AR application

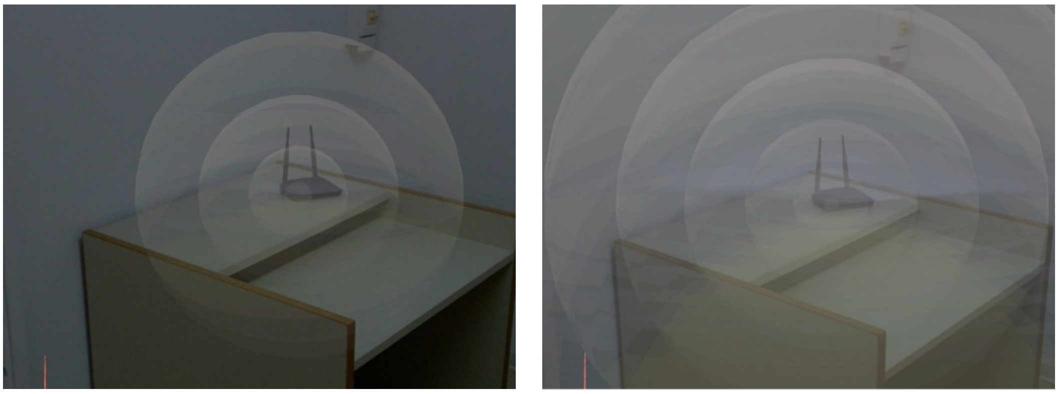

Figure 29. Electromagnetic waves expanding from router as virtual objects in the physical environment of the AR application

Figure 30. Electromagnetic waves expanding from mobile phone (left) and from DECT phone (right) as virtual objects in the physical environment of the AR application

Figure 31. Electromagnetic waves expanding from laptop and router at the same time in the AR application

Figure 32. Electromagnetic waves expanding from laptop, mobile phone and DECT phone at the same time in the AR application

3.4.4. AR TECHNOLOGY

For the purposes of this study the Magic Leap One AR headset was used. This device is a combination of augmented reality see-through glasses and a standalone computer. It runs on Lumin OS which is a spatial operating system that can recognize and understand different environments, power high fidelity visuals, and ensure that digital content mixes appropriately with the real world. The device utilizes state of the art hardware such as 64-bit CPU, 256 CUDA cores GPU, 128 GB storage and a number of self-contained, head-mounted sensors and cameras. It is a standalone device that doesn't require connection with a PC.

As mentioned in the introduction of this chapter, the empirical study consisted of two parts/activities. An activity with the AR application and an activity with the VR application. The design and description of the VR application follows.

3.4.5. VR APPLICATION DESIGN

For the development of the VR application, Unity 3D and C# were used.

3.4.6. VR APPLICATION – ELECTROMAGNETIC FIELDS

The VR application was created to simulate the physical environment of the AR application. All the real objects and the devices in the AR activity were designed as digital objects in the VR application. The cell phone, DECT phone, laptop and a router were placed in the same locations as the physical environment of the AR activity (figure 33).

Figure 33. Virtual environment of the VR application

By wearing the Oculus Rift S device, the participants were able to see the environment digitally and were also able by the same way as in the AR activity, namely by pointing each of the digital objects by the remote control of Oculus Rift S, to turn on/off the devices and enable/disable the corresponding wave visualization of each device. The electromagnetic waves were visualized as a set of concentric spheres centered on each device and expanding in all directions, as well as in the AR activity (figures 34-39).

Figure 34. User pointing the remote controller to the laptop in the VR application

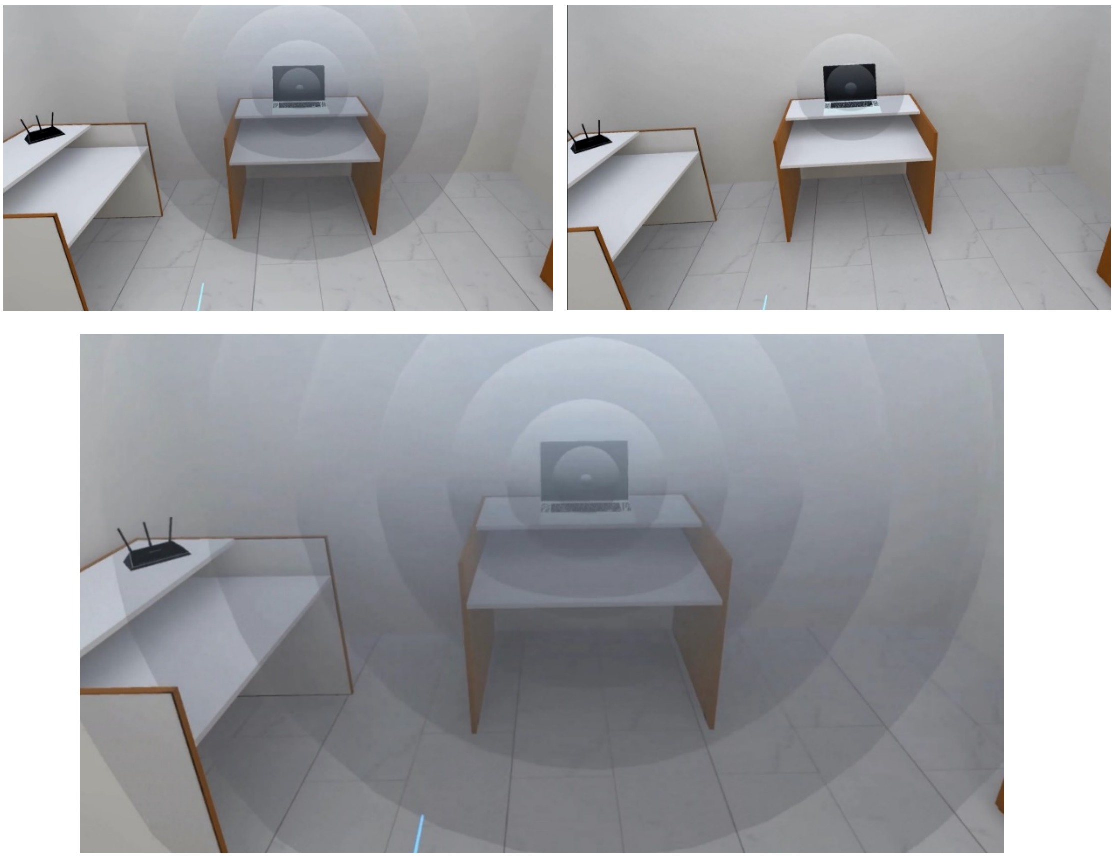

Figure 35. Electromagnetic waves expanding from laptop as virtual objects in the virtual environment of the VR application

Figure 36. Electromagnetic waves expanding from router as virtual objects in the virtual environment of the VR application

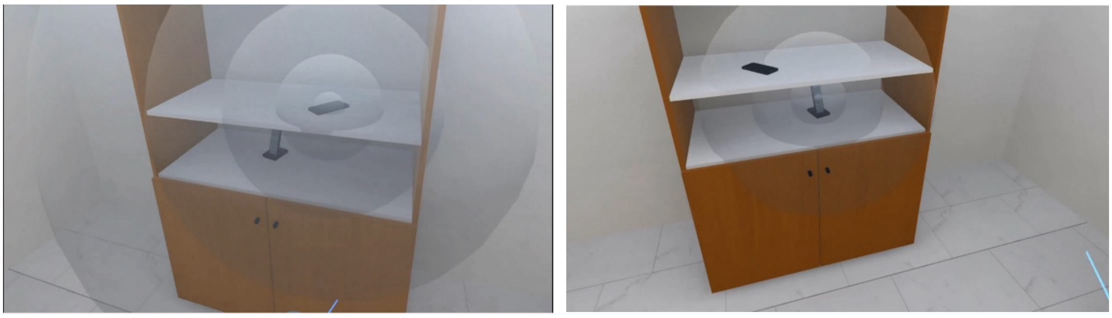

Figure 37. Electromagnetic waves expanding from mobile phone (left) and from DECT phone (right) as virtual objects in the virtual environment of the VR application

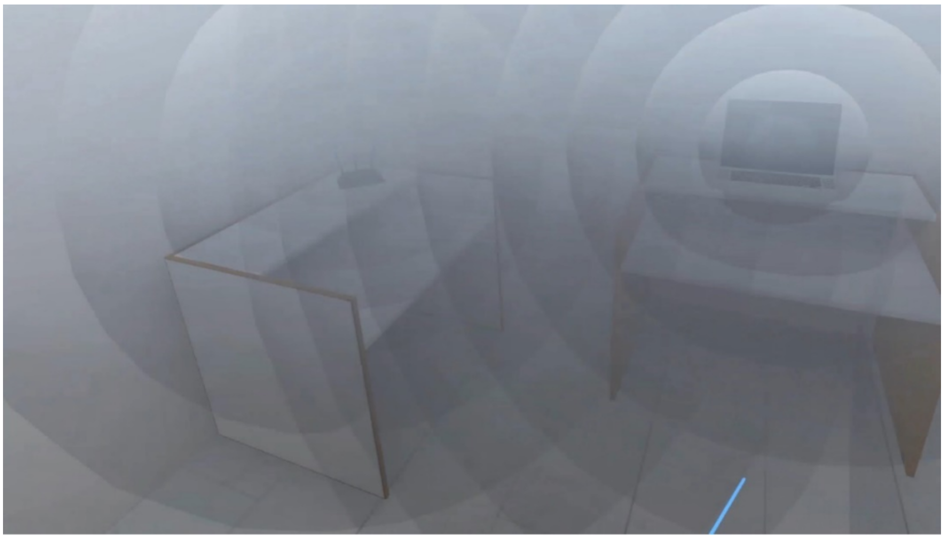

Figure 38. Electromagnetic waves expanding from laptop and router at the same time in the VR application

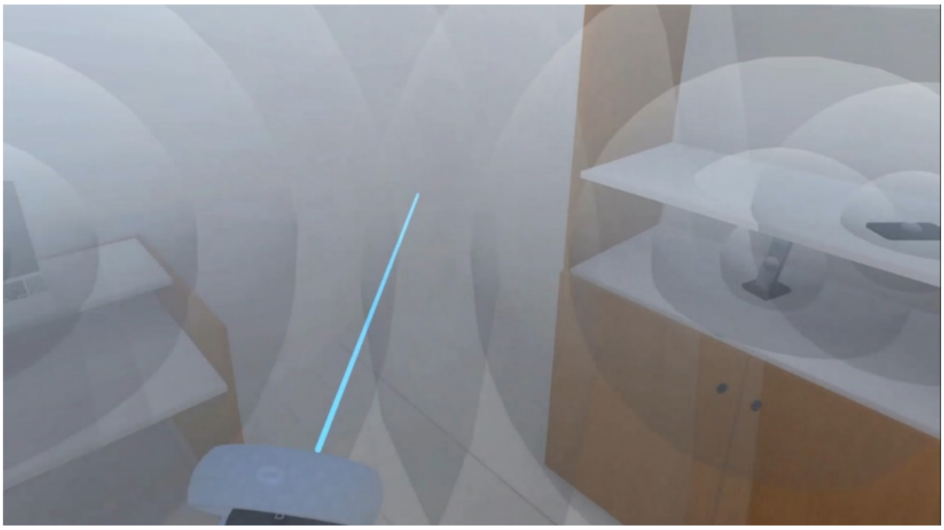

Figure 39. Electromagnetic waves expanding from laptop, mobile phone and DECT phone at the same time in the AR application

3.4.7. VR TECHNOLOGY

For the purposes of this study the Oculus Rift S, a 3D virtual reality (VR) head-mounted display (HMD), was used. The Oculus Rift S embeds a 3D inertial sensor (IS) and uses a customized algorithm developed by Oculus VR to track and monitor head movement so the content displayed can be compensated in an immersive VR environment (Parkin, 2014). Oculus Rift S can be used as a standalone device that doesn't require connection with a PC.

3.5. EXPERIMENTAL PROCEDURE

The empirical study took place in a dedicated room at the Educational Approaches to Virtual Reality Technologies laboratory (earthlab), University of Ioannina, Greece. The room was divided with dividers for the AR and the VR activities as well as for filling the corresponding questionnaires.

Initially, the researcher gave the participants some information about the study. They would participate in two activities, in an AR and VR activity where they would be able to turn on/off wireless devices such as a laptop, a router, a DECT phone and a cell phone and by this way enable/disable the corresponding wave visualization of each device. In addition, the participants were told that they would fill two same questionnaires, one for the AR activity and the same questionnaire (modified/adjusted) for the VR activity right after each activity. Half of the participants (23 out of 47) did the AR activity first, then filled the AR questionnaire, followed by the VR activity and the VR questionnaire, whereas the other half (24 out of 47) did the VR activity first, then filled the VR questionnaire, followed by the AR activity and AR questionnaire.

3.5.1. AR ACTIVITY

The researcher started the procedure by showing the AR device (Magic Leap One) to the participants as well as the Magic Leap One remote control. In addition, the researcher explained to the participants which buttons they should press to choose the application as well as to turn on/off the devices in the AR application. After this, the researcher was helping the participants wear the AR device and give instructions to choose the relevant application. In some cases, the AR device did not recognize the space due to different users using the device. In those cases, the researcher gave the students instructions in order the space to be recognized (figure 40).

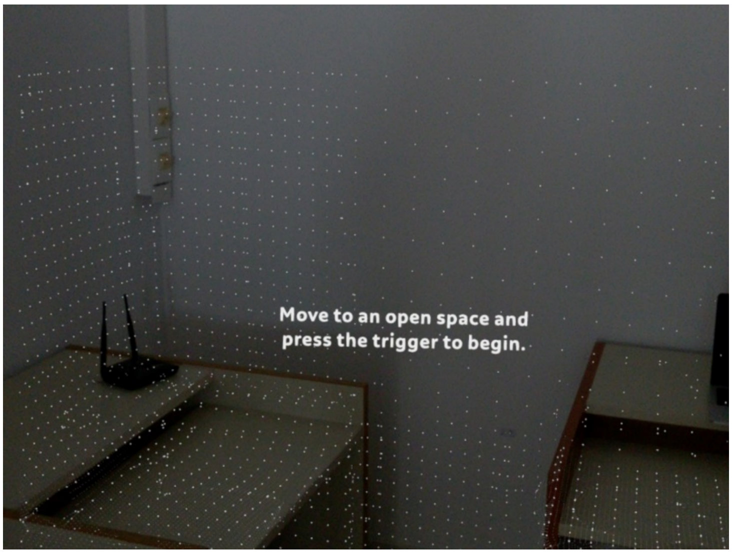

Figure 40. The AR device displaying spots in the physical environment to recognize the space. The participant should look at different directions and move in order the space to be recognized

During the procedure, each participant was standing up and free to move around the room. After observing the physical environment for a while, the participant could turn on and off all the devices by pointing the remote control of the Magic Leap One device on each emitting device. The participant could turn on and off the cell phone, the DECT phone, the laptop, and the router in any order and as long as they would prefer, whereas they were moving around the room (figure 41). After turning on each device, the researcher asked the participant to refer what he/she was observing and what he/she thought this was. The activity lasted about 10 minutes.

Figure 41. A participant during the AR activity wearing the AR headset

At the end, the researcher helped the participants to remove the headset and administered them the AR questionnaire. After completing the filling of the AR questionnaire, which used to last about 10 minutes, the participants were asked to move to the other part of the room to start the VR activity.

3.5.2. VR ACTIVITY

The researcher started the activity by showing the VR device (Oculus Rift S) to the participants as well as the Oculus Rift S remote control. In addition, the researcher explained to the participants which buttons they should press to turn on/off the virtual devices. In the VR application the users did not have to choose the application as in the AR activity, as it was possible for the activity to be started by the researcher from a PC. After this, the researcher was helping the participants wear the VR device.

During the procedure, each participant was standing up and free to move around the room. After observing the digital environment for a while, the participant could turn on and off all the devices by pointing the remote control of the Oculus Rift S on each emitting device. The participant could turn on the cell phone, the DECT phone, the laptop and the router in any order and as long as they would prefer, whereas they were moving around the room (figure 42). After turning on each device, the researcher asked the participant to refer what he/she was observing and what he/she thought this was. The activity lasted about 10 minutes.

Figure 42. User during the VR activity wearing the VR headset

At the end, the researcher helped the participant to remove the headset and administered them the VR questionnaire. The procedure of filling the VR questionnaire, used to last about 10 minutes.

All the experimental procedure (AR activity, AR questionnaire, VR activity, VR questionnaire), lasted about 40 minutes per participant.

3.6. DATA COLLECTION

3.6.1. AR APPLICATION

A questionnaire was used for the data collection of the empirical study (Appendix A). The questionnaire consisted of three parts.

The first part included demographic information such as gender, age and experience in computer use, AR and VR applications.

The second part consisted of 29 items for the eight variables proposed by the Mobile Augmented Reality Acceptance Model (MARAM) (Koutromanos & Mikropoulos, 2021), which was developed as an extension of the TAM model (Davis, 1989) adjusted for Mobile Augmented Reality Applications. The MARAM was chosen as it examines the factors of technology acceptance such as intention, attitude, perceived ease of use, perceived usefulness, perceived relative advantage, facilitating conditions and mobile self-efficacy, and showed that specific variables predicted approximately 50% of the variance among dependent variables regarding the intention, which is a very high percentage compared to previous Technology Acceptance Model studies (Koutromanos & Mikropoulos, 2021). The MARAM questionnaire was used to explore the effects of the technological affordances of Augmented Reality trough users' technology acceptance. Both AR and VR devices used for the current empirical study are considered mobile devices as they are standalone devices that do not require connection with a PC. All the items of the 8 variables (intention, attitude, perceived ease of use, perceived usefulness, perceived relative advantage, facilitating conditions, mobile self-efficacy) were measured using a 5-point Likert scale (1=Strongly disagree to 5=Strongly agree).

The third part of the questionnaire referred to the participants' sense of Spatial Presence and Simulator Sickness.

Spatial Presence was measured with the Temple Presence Inventory (TPI) which uses a 7-item 7-point Likert scale (Lombart, Bolmarcich, & Weinstein, 2009). TPI was designed for virtual environments, so it was modified to the context of the current AR activity as follows (Vrellis et al., 2020):

1. the references to "objects or people" were replaced by "virtual waves"
2. the scale of the last question that evaluates the resemblance of the virtual experience between looking at a screen or through a window was replaced by the dipole screen/real world
3. the question regarding sound directionality was not used, because no sound effects were used in the activity.

Simulator sickness (SS) was measured with the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993), a 16-item 4-point Likert scale. SSQ provides three distinct symptom clusters: Nausea (i.e., nausea, stomach awareness, increased salivation, burping), Oculomotor (i.e., eyestrain, difficulty focusing, blurred vision, headache) and Disorientation (i.e., dizziness, vertigo).

3.6.2. VR APPLICATION

The same questionnaire was used for the VR application. The only difference from the AR questionnaire was that the word AR was replaced with VR.

The questionnaires were created and delivered through Google Forms.

3.7. DATA ANALYSIS

The data collected from the empirical study were analyzed as following:

- Kolmogorov Smirnov normality tests were applied on all variables to test the normality of the variables.
- Cronbach's coefficient alpha was used to examine the reliability of the variables.
- Descriptive analysis was conducted by calculating the mean (M) and the standard deviation (SD) of the variables of the AR and VR questionnaire.
- Spearman correlation was applied to find out statistically significant relationships between the eight variables of the second part of the AR and VR questionnaire.
- Regression analysis was conducted to examine the direct effects of: (a) perceived usefulness, attitude and facilitating conditions on intention, (b) perceived ease of use, perceived usefulness and perceived enjoyment on attitude, (c) perceived relative advantage, perceived enjoyment and perceived ease of use in perceived usefulness, and (d) facilitating conditions and mobile self-efficacy on perceived ease of use regarding AR and VR.
- ANOVA was applied to find out statistically significant relationships between the variables of the second part of the AR and VR questionnaire.
- ANOVA was applied to find out statistically significant relationships between the variables of the third part of the AR and VR questionnaire.

  The dataset was analyzed using SPSS V26.

CHAPTER IV: RESULTS

4.1. NORMALITY TEST

Kolmogorov Smirnov normality test was applied on all variables of the AR and VR questionnaire to test the normality of the variables.

The results of the normality tests showed that the variables were not normally distributed.

The detailed results are presented in the APPENDIX B.

4.2. CRONBACH'S ALPHA TEST

Cronbach's Alpha test was applied to check the reliability of the variables for the AR and VR questionnaires.

AR questionnaire variables

Table 7. Cronbach's Alpha test for Intention (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.794	3

Since the value of Cronbach's Alpha test for the 3 variables of Intention is .794 (table 7), these variables are acceptable for statistical analysis.

Table 8. Cronbach's Alpha test for Attitude (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.774	3

Since the value of Cronbach's Alpha test for the 3 variables of Attitude is .774 (table 8), it indicates that these variables are acceptable for statistical analysis.

Table 9. Cronbach's Alpha test for Perceived ease of use (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.792	3

Since the value of Cronbach's Alpha test for the 3 variables of Perceived ease of use is .792 (table 9), it indicates that these variables are acceptable for statistical analysis.

Table 10. Cronbach's Alpha test for Perceived usefulness (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.886	3

Since the value of Cronbach's Alpha test for the 3 variables of Perceived usefulness is .886 (table 10), it indicates that these variables are good for statistical analysis.

Table 11. Cronbach's Alpha test for Perceived relative advantage (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.866	5

Since the value of Cronbach's Alpha test for the 5 variables of Perceived relative advantage is .866 (table 11), it indicates that these variables are good for statistical analysis.

Table 12. Cronbach's Alpha test for Facilitating Conditions (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.698	3

Since the value of Cronbach's Alpha test for the 3 variables of Facilitating Conditions is .698 (table 12), it indicates that these variables are acceptable for statistical analysis.

Table 13. Cronbach's Alpha test for perceived enjoyment (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.873	4

Since the value of Cronbach's Alpha test for the 4 variables of perceived enjoyment is .873 (table 13), it indicates that these variables are good for statistical analysis.

Table 14. Cronbach's Alpha test for mobile self-efficacy (Augmented Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.716	5

Since the value of Cronbach's Alpha test for the 5 variables of mobile self-efficacy is .873 (table 14), it indicates that these variables are acceptable for statistical analysis.

VR questionnaire variables

Table 15. Cronbach's Alpha test for Intention (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.734	3

Since the value of Cronbach's Alpha test for the 3 variables of Intention is .734 (table 15), it indicates that these variables are acceptable for statistical analysis.

Table 16. Cronbach's Alpha test for Attitude (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.825	3

Since the value of Cronbach's Alpha test for the 3 variables of attitude is .825 (table 16), it indicates that these variables are good for statistical analysis.

Table 17. Cronbach's Alpha test for Perceived ease of use (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.705	3

Since the value of Cronbach's Alpha test for the 3 variables of Perceived ease of use is .705 (table 17), it indicates that these variables are acceptable for statistical analysis.

Table 18. Cronbach's Alpha test for Perceived usefulness (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.823	3

Since the value of Cronbach's Alpha test for the 3 variables of Perceived usefulness is .823 (table 18), it indicates that these variables are good for statistical analysis.

Table 19. Cronbach's Alpha test for Perceived relative advantage (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.861	5

Since the value of Cronbach's Alpha test for the 5 variables of Perceived relative advantage is .861 (table 19), it indicates that these variables are good for statistical analysis.

Table 20. Cronbach's Alpha test for facilitating conditions (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.566	3

Since the value of Cronbach's Alpha test for the 3 variables of facilitating conditions is .566 (table 20), it indicates that these variables are poor for statistical analysis.

Table 21. Cronbach's Alpha test for perceived enjoyment (Virtual Reality)

Reliability Statistics

Cronbach's Alpha	N of Items
.897	4

Since the value of Cronbach's Alpha test for the 4 variables of perceived enjoyment is .897 (table 21), it indicates that these variables are good for statistical analysis.

Table 22. Cronbach's Alpha test for mobile self-efficacy (Virtual Reality)

Reliability Statistics	
Cronbach's Alpha	N of Items
.620	5

Since the value of Cronbach's Alpha test for the 5 variables of mobile self-efficacy is .620 (table 22), it indicates that these variables are acceptable for statistical analysis.

4.3. Descriptive Statistics of AR questionnaire

A total of 47 individuals participated in the survey. Five-point Likert scale is considered as the interval scale. Hence 1 – 1.8 means strongly disagree. 1.8 – 2.4 means disagree. 2.4 – 3.2 means neutral. 3.2 – 4.0 means agree, and 4.0 – 4.8 means strongly agree.

Table 23 shows the mean value and the standard deviation for each question of the variable Intention.

Table 23. Descriptive statistics for Intention of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B1: Intention [I intend to use AR applications in my future teaching.]	47	4.23	.598
Section B1: Intention [I plan to use AR applications in my future teaching.]	47	3.98	.794

Section B1: Intention [I predict I would use AR applications in my future teaching.]	47	3.94	.818

The mean value for the first question is 4.23, which indicates that on average, participants were strongly agreed on using AR applications in their future teaching. The standard deviation value is .598, which indicates that there is low variation in participants using AR applications in their future teaching.

The mean value for the second question is 3.98, which indicates that on average, participants were agreed on planning to use AR applications in their future teaching. The standard deviation value is .794, which indicates that there is low variation in participants on planning to use AR applications in their future teaching.

The mean value for the third question is 3.94, which indicates that on average, participants agreed that they predict to use AR applications in their future teaching. The standard deviation value is .818, which indicates that there is low variation in participants on predicting to use AR applications in their future teaching.

Table 24 shows the mean value and the standard deviation for each question of the variable Attitude.

Table 24. Descriptive statistics for Attitude of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B2: Attitude [Using AR applications is a good idea.]	47	4.45	.503
Section B2: Attitude [I like using AR applications.]	47	4.19	.741
Section B2: Attitude [It is desirable to use AR applications.]	47	4.30	.548

The mean value for the first question is 4.45, which indicates that on average, participants strongly agree that using AR applications is a good idea. The standard deviation value is .503, which indicates that there is low variation in participants' attitude that using AR applications is a good idea.

The mean value for the second question is 4.19, which indicates that on average, participants strongly agree that they like using AR applications. The standard deviation value is .741, which indicates that there is low variation in participants' attitude that they like using AR applications.

The mean value for the third question is 4.30, which indicates that on average, participants strongly agree that it is desirable to use AR applications. The standard deviation value is .548, which indicates that there is low variation in participants' attitude that it is desirable to use AR applications.

Table 25 shows the mean value and the standard deviation for each question of the variable Perceived ease of use.

Table 25. Descriptive statistics for Perceived ease of use of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B3: Perceived ease of use [My interaction with AR applications is clear and understandable.]	47	3.89	.759
Section B3: Perceived ease of use [It is easy for me to become skillful at using AR applications.]	47	3.70	.832
Section B3: Perceived ease of use [I find AR applications easy to use.]	47	3.57	.878

The mean value for the first question is 3.89, which indicates that on average, participants agree that their interaction with AR applications is clear and understandable. The standard deviation value is .759, which indicates that there is low variation in participants' Perceived ease of use that their interaction with AR applications is clear and understandable.

The mean value for the second question is 3.70, which indicates that on average, participants agree that it is easy for them to become skillful at using AR applications. The standard deviation value is .832, which indicates that there is low variation in participants' Perceived ease of use that it is easy for them to become skillful at using AR applications.

The mean value for the third question is 3.57, which indicates that on average, participants agree that they find AR applications easy to use. The standard deviation value is .878, which indicates that there is low variation in participants' Perceived ease of use that they find AR applications easy to use.

Table 26 shows the mean value and the standard deviation for each question of the variable Perceived usefulness.

Table 26. Descriptive statistics for Perceived usefulness of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B4: Perceived usefulness [Using AR applications enhances my teaching effectiveness.]	47	4.30	.587
Section B4: Perceived usefulness [AR applications are useful for my teaching.]	47	4.11	.561
Section B4: Perceived usefulness [Using AR applications increases my teaching productivity.]	47	4.15	.691

The mean value for the first question is 4.30, which indicates that on average, participants strongly agree that Using AR applications enhances their teaching effectiveness. The standard deviation value is .587, which indicates that there is low variation in participants' Perceived usefulness that using AR applications enhances their teaching effectiveness.

The mean value for the second question is 4.11, which indicates that on average, participants strongly agree that AR applications are useful for their teaching. The standard deviation value is .561, which indicates that there is low variation in participants' Perceived usefulness that AR applications are useful for their teaching.

The mean value for the third question is 4.15, which indicates that on average, participants strongly agree that using AR applications increases their teaching productivity. The standard deviation value is .691, which indicates that there is low variation in participants' Perceived usefulness that using AR applications increases their teaching productivity.

Table 27 shows the mean value and the standard deviation for each question of the variable Perceived relative advantage.

Table 27. Descriptive statistics for Perceived relative advantage of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B5: Perceived relative advantage [AR applications would be more advantageous in my teaching than other technologies.]	47	3.98	.794
Section B5: Perceived relative advantage [AR applications would make my teaching more effective than other technologies.]	47	3.87	.741
Section B5: Perceived relative advantage [AR applications are relatively efficient in my teaching compared to existing technologies.]	47	3.85	.751

Section B5: Perceived relative advantage [The use of AR applications offers new learning opportunities compared to existing technologies.]	47	4.26	.820
Section B5: Perceived relative advantage [Overall, AR applications are better than existing technologies.]	47	3.79	.883

The mean value for the first question is 3.98, which indicates that on average, participants agree that AR applications would be more advantageous in their teaching than other technologies. The standard deviation value is .794, which indicates that there is low variation in participants' Perceived relative advantage that AR applications would be more advantageous in their teaching than other technologies.

The mean value for the second question is 3.87, which indicates that on average, participants agree that AR applications would make their teaching more effective than other technologies. The standard deviation value is .741, which indicates that there is low variation in participants' Perceived relative advantage that AR applications would make their teaching more effective than other technologies.

The mean value for the third question is 3.85, which indicates that on average, participants agree that AR applications are relatively efficient in my teaching compared to existing technologies. The standard deviation value is .751, which indicates that there is low variation in participants' Perceived relative advantage that AR applications are relatively efficient in their teaching compared to existing technologies.

The mean value for the fourth question is 4.26, which indicates that on average, participants agree that the use of AR applications offers new learning opportunities compared to existing technologies. The standard deviation value is .820, which indicates that there is low variation in participants' Perceived usefulness that the use of AR applications offers new learning opportunities compared to existing technologies.

The mean value for the fifth question is 3.79, which indicates that on average, participants agree that overall, AR applications are better than existing technologies. The standard deviation value is .883, which indicates that there is low variation in participants' Perceived usefulness that overall, AR applications are better than existing technologies.

Table 28 shows the mean value and the standard deviation for each question of the variable Facilitating conditions.

Table 28. Descriptive statistics for Facilitating conditions of AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B6: Facilitating conditions [I have the resources (e.g., Internet connection, tablets) necessary to use AR applications in my teaching.]	47	3.64	1.092
Section B6: Facilitating conditions [I have the knowledge needed to use AR applications in my teaching.]	47	3.19	.992
Section B6: Facilitating conditions [I have the time needed to use AR applications in my teaching.]	47	3.70	.931

The mean value for the first question is 3.64, which indicates that on average, participants agree that they have the resources (e.g., Internet connection, tablets) necessary to use AR applications in their teaching. The standard deviation value is 1.092, which indicates that there is high variation in participants' facilitating conditions that they have the resources (e.g., Internet connection, tablets) necessary to use AR applications in their teaching.

The mean value for the second question is 3.19, which indicates that on average, participants agree that they have the knowledge needed to use AR applications in their teaching. The standard deviation value is .992, which indicates that there is low variation in participants' facilitating conditions that they have the knowledge needed to use AR applications in their teaching.

The mean value for the third question is 3.70, which indicates that on average, participants agree that they have the time needed to use AR applications in their teaching. The standard deviation value is .931, which indicates that there is low variation in participants' facilitating conditions that they have the time needed to use AR applications in their teaching.

Table 29 shows the mean value and the standard deviation for each question of the variable Perceived enjoyment.

Table 29. Descriptive statistics for Perceived enjoyment for AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B7: Perceived enjoyment [Using AR applications is truly fun.]	47	4.62	.534
Section B7: Perceived enjoyment [I know using AR applications to be enjoyable.]	47	4.53	.546
Section B7: Perceived enjoyment [The use of AR applications gives me pleasure.]	47	4.43	.773
Section B7: Perceived enjoyment [The use of AR applications makes me feel good.]	47	4.36	.819

The mean value for the first question is 4.62, which indicates that on average, participants strongly agree that using AR applications is truly fun. The standard deviation value is .534, which indicates that there is low variation in participants' perceived enjoyment that using AR applications is truly fun.

The mean value for the second question is 4.53, which indicates that on average, participants strongly agree that they know using AR applications to be enjoyable. The standard deviation value is .546, which indicates that there is low variation in participants' perceived enjoyment that they know using AR applications to be enjoyable.

The mean value for the third question is 4.43, which indicates that on average, participants strongly agree that the use of AR applications gives them pleasure. The standard deviation value is .773, which indicates that there is low variation in participants' perceived enjoyment that the use of AR applications gives them pleasure. The mean value for the fourth question is 4.36, which indicates that on average, participants strongly agree that the use of AR applications makes them feel good. The standard deviation value is .819, which indicates that there is low variation in participants' perceived enjoyment that the use of AR applications makes them feel good.

Table 30 shows the mean value and the standard deviation for each question of the variable Mobile Self-Efficacy.

Table 30. Descriptive statistics for Mobile Self-Efficacy for AR application

Descriptive Statistics			
	N	Mean	Std. Deviation
Section B8: Mobile Self-Efficacy [I could complete a job or task using a mobile device.]	47	3.81	.798
Section B8: Mobile Self-Efficacy [I could complete a job or task using a mobile device if someone showed me how to do it.]	47	4.26	.736
Section B8: Mobile Self-Efficacy [I was fully able to use a mobile device before I began using AR applications.]	47	3.77	.914
Section B8: Mobile Self-Efficacy [I am confident that I can effectively use AR applications using mobile technology.]	47	3.53	.881
Section B8: Mobile Self-Efficacy [I believe I can use AR applications using mobile technology even if I have never used a similar technology before.]	47	3.47	.975

The mean value for the first question is 3.81, which indicates that on average, participants agree that they could complete a job or task using a mobile device. The standard deviation value is .798, which indicates that there is low variation in participants' mobile self-efficacy that they could complete a job or task using a mobile device.

The mean value for the second question is 4.26, which indicates that on average, participants agree that they could complete a job or task using a mobile device if someone showed them how to do it. The standard deviation value is .736, which indicates that there is low variation in participants' mobile self-efficacy that they could complete a job or task using a mobile device if someone showed them how to do it.

The mean value for the third question is 3.77, which indicates that on average, participants agree that they were fully able to use a mobile device before they began using AR applications. The standard deviation value is .914, which indicates that there is low variation in participants' mobile self-efficacy that they were fully able to use a mobile device before they began using AR applications.

The mean value for the fourth question is 3.53, which indicates that on average, participants agree that they are confident that they can effectively use AR applications using mobile technology. The standard deviation value is .881, which indicates that there is low variation in participants' mobile self-efficacy that they are confident that they can effectively use AR applications using mobile technology.

The mean value for the fifth question is 3.47, which indicates that on average, participants agree that they believe they can use AR applications using mobile technology even if they have never used a similar technology before. The standard deviation value is .975, which indicates that there is low variation in participants' mobile self-efficacy that they believe they can use AR applications using mobile technology even if they have never used a similar technology before.

4.4. Descriptive Statistics of VR Questionnaire

Table 31 shows the mean value and the standard deviation for each question of the variables Intention and Attitude.

Table 31. Descriptive statistics for Intention and Attitude of VR application

Descriptive Statistics			
	Mean	Std. Deviation	N
Intention [I intend to use VR applications in my future teaching.]	4.23	.633	47
Intention [I plan to use VR applications in my future teaching.]	3.87	.797	47
Intention [I predict I would use VR applications in my future teaching.]	4.00	.692	47
Attitude [Using VR applications is a good idea.]	4.51	.547	47
Attitude [I like using VR applications.]	4.36	.673	47
Attitude [It is desirable to use VR applications.]	4.38	.610	47

The mean value (for Intention [I intend to use VR applications in my future teaching.]) is 4.23, which indicates that on average participants were strongly agree that they intend to use VR applications in their future teaching. The standard deviation value is .633, which indicates that there was low variation in participants' intention that they intend to use VR applications in their future teaching.

The mean value (Intention [I plan to use VR applications in my future teaching.]) is 3.87, which indicates that on average participants were agree that they plan to use VR applications in their future teaching. The standard deviation value is .797, which indicates that there was low variation in participants' intention that they plan to use VR applications in my future teaching.

The mean value (Intention [I predict I would use VR applications in my future teaching.]) is 4.00, which indicates that on average participants were strongly agree that they predict they would use VR applications in their future teaching. The standard deviation value is .692, which indicates that there was low variation in participants' intention that that they predict they would use VR applications in their future teaching.

The mean value (Attitude [Using VR applications is a good idea.]) is 4.51, which indicates that on average participants were strongly agree that using VR applications is a good idea. The standard deviation value is .547, which indicates that there was low variation in participants' attitude that using VR applications is a good idea.

The mean value (Attitude [I like using VR applications.]) is 4.36, which indicates that on average participants were strongly agree that they like using VR applications. The standard deviation value is .673, which indicates that there was low variation in participants' attitude that they like using VR applications.

The mean value (Attitude [It is desirable to use VR applications.]) is 4.38, which indicates that on average participants were strongly agree that it is desirable to use VR applications. The standard deviation value is .610, which indicates that there was low variation in participants' attitude that it is desirable to use VR applications.

Table 32 shows the mean value and the standard deviation for each question of the variables Perceived ease of use, Perceived usefulness and Perceived relative advantage.

Table 32. Descriptive statistics for Ease of use, Perceived usefulness and Perceived relative advantage of VR application

Descriptive Statistics			
	Mean	Std. Deviation	N
Perceived ease of use [My interaction with VR applications is clear and understandable.]	4.17	.789	47
Perceived ease of use [It is easy for me to become skillful at using VR applications.]	3.72	.949	47
Perceived ease of use [I find VR applications easy to use.]	3.74	.988	47
Perceived usefulness [Using VR applications enhances my teaching effectiveness.]	4.21	.657	47
Perceived usefulness [VR applications are useful for my teaching.]	4.23	.666	47
Perceived usefulness [Using VR applications increases my teaching productivity.]	4.17	.670	47
Perceived relative advantage [VR applications would be more advantageous in my teaching than other technologies.]	4.02	.707	47
Perceived relative advantage [VR applications would make my teaching more effective than other technologies.]	3.91	.775	47
Perceived relative advantage [VR applications are relatively efficient in my teaching compared to existing technologies.]	3.94	.763	47

Perceived relative advantage [The use of VR applications offers new learning opportunities compared to existing technologies.]	4.34	.700	47
Perceived relative advantage [Overall, VR applications are better than existing technologies.]	3.96	.977	47

The mean value (Perceived ease of use [My interaction with VR applications is clear and understandable.]) is 4.17, which indicates that on average participants were strongly agree that their interaction with VR applications is clear and understandable. The standard deviation value is .789, which indicates that there was low variation in participants' Perceived ease of use that their interaction with VR applications is clear and understandable.

The mean value (Perceived ease of use [It is easy for me to become skillful at using VR applications.]) is 3.72, which indicates that on average participants were agree that it is easy for them to become skillful at using VR applications. The standard deviation value is .949, which indicates that there was low variation in participants' Perceived ease of use that it is easy for them to become skillful at using VR applications.

The mean value (Perceived ease of use [I find VR applications easy to use.]) is 3.74, which indicates that on average participants were agree that they find VR applications easy to use. The standard deviation value is .988, which indicates that there was low variation in participants' Perceived ease of use that they find VR applications easy to use.

The mean value (Perceived usefulness [Using VR applications enhances my teaching effectiveness.]) is 4.21, which indicates that on average participants were strongly agree that using VR applications enhances their teaching effectiveness. The standard deviation value is .657, which indicates that there was low variation in participants' Perceived usefulness using VR applications enhances their teaching effectiveness.

The mean value (Perceived usefulness [VR applications are useful for my teaching.]) is 4.23, which indicates that on average participants were strongly agree that using VR applications are useful for their teaching. The standard deviation value is .666, which indicates that there was low variation in participants' Perceived usefulness VR applications are useful for their teaching.

The mean value (Perceived usefulness [Using VR applications increases my teaching productivity.]) is 4.17, which indicates that on average participants were strongly agree that using VR applications increases my teaching productivity. The standard deviation value is .670, which indicates that there was low variation in participants' Perceived usefulness using VR applications increases my teaching productivity.

The mean value (Perceived relative advantage [VR applications would be more advantageous in my teaching than other technologies.]) is 4.02, which indicates that on average participants were strongly agree that VR applications would be more advantageous in their teaching than other technologies. The standard deviation value is .707, which indicates that there was low variation in participants' PU that VR applications would be more advantageous in their teaching than other technologies.

The mean value (VR applications would make my teaching more effective than other technologies) is 3.91, which indicates that on average participants were agree that VR applications would make their teaching more effective than other technologies. The standard deviation value is .775, which indicates that there was low variation in participants' PU that VR applications would make my teaching more effective than other technologies.

The mean value (Perceived relative advantage [VR applications are relatively efficient in my teaching compared to existing technologies.]) is 3.94, which indicates that on average participants were agree that VR applications are relatively efficient in their teaching compared to existing technologies. The standard deviation value is .763, which indicates that there was low variation in participants' PRA that VR applications are relatively efficient in their teaching compared to existing technologies.

The mean value (Perceived relative advantage [The use of VR applications offers new learning opportunities compared to existing technologies.]) is 4.34, which indicates that on average participants were agree that the use of VR applications offers new learning opportunities compared to existing technologies. The standard deviation value is .700, which indicates that there was low variation in participants' PRA the use of VR applications offers new learning opportunities compared to existing technologies.

The mean value (Perceived relative advantage [Overall, VR applications are better than existing technologies.]) is 3.96, which indicates that on average participants were agree that overall, VR applications are better than existing technologies. The standard deviation value is .977, which indicates that there was low variation in participants' PRA overall, VR applications are better than existing technologies.

Table 33 shows the mean value and the standard deviation for each question of the variables Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy.

Table 33. Descriptive statistics for Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy of VR application

Descriptive Statistics			
	Mean	Std. Deviation	N
Facilitating conditions [I have the resources (e.g., Internet connection, tablets) necessary to use VR applications in my teaching.]	3.68	1.086	47
Facilitating conditions [I have the knowledge needed to use VR applications in my teaching.]	3.23	1.005	47
Facilitating conditions [I have the time needed to use VR applications in my teaching.]	3.43	.878	47
Perceived enjoyment [Using VR applications is truly fun.]	4.70	.587	47
Perceived enjoyment [I know using VR applications to be enjoyable.]	4.64	.640	47
Perceived enjoyment [The use of VR applications gives me pleasure.]	4.47	.747	47
Perceived enjoyment [The use of VR applications makes me feel good.]	4.43	.801	47
Mobile Self-Efficacy [I could complete a job or task using a mobile device.]	3.89	.759	47
Mobile Self-Efficacy [I could complete a job or task using a mobile device if someone showed me how to do it.]	4.40	.681	47

Mobile Self-Efficacy [I was fully able to use a mobile device before I began using VR applications.]	3.85	1.021	47
Mobile Self-Efficacy [I am confident that I can effectively use VR applications using mobile technology.]	3.49	.804	47
Mobile Self-Efficacy [I believe I can use VR applications using mobile technology even if I have never used a similar technology before.]	3.36	1.009	47

The mean value (Facilitating conditions [I have the resources (e.g., Internet connection, tablets) necessary to use VR applications in my teaching.]) is 3.68, which indicates that on average participants were agree that they have the resources (e.g., Internet connection, tablets) necessary to use VR applications in their teaching. The standard deviation value is 1.086, which indicates that there was high variation in participants' facilitating conditions that they have the resources (e.g., Internet connection, tablets) necessary to use VR applications in their teaching.

The mean value (Facilitating conditions [I have the knowledge needed to use VR applications in my teaching.]) is 3.23, which indicates that on average participants were agree that they have the knowledge needed to use VR applications in their teaching. The standard deviation value is 1.005, which indicates that there was high variation in participants' facilitating conditions that they have the knowledge needed to use VR applications in their teaching.

The mean value (Facilitating conditions [I have the time needed to use VR applications in my teaching.]) is 3.43, which indicates that on average participants were agree that they have the time needed to use VR applications in their teaching. The standard deviation value is .878, which indicates that there was low variation in participants' facilitating conditions that they have the time needed to use VR applications in their teaching.

The mean value (Perceived enjoyment [Using VR applications is truly fun.]) is 3.70, which indicates that on average participants were agree that using VR applications is truly fun. The standard deviation value is .587, which indicates that there was low variation in participants' perceived enjoyment that using VR applications is truly fun.

The mean value (Perceived enjoyment [I know using VR applications to be enjoyable.]) is 4.64, which indicates that on average participants strongly agree that they know using VR applications to be enjoyable. The standard deviation value is .64, which indicates that there was low variation in participants' perceived enjoyment that they know using VR applications to be enjoyable.

The mean value (Perceived enjoyment [The use of VR applications gives me pleasure.]) is 4.47, which indicates that on average participants strongly agree that the use of VR applications gives them pleasure. The standard deviation value is .747, which indicates that there was low variation in participants' perceived enjoyment that the use of VR applications gives them pleasure.

The mean value (Perceived enjoyment [The use of VR applications makes me feel good.]) is 4.43, which indicates that on average participants strongly agree that the use of VR applications makes them feel good. The standard deviation value is .801, which indicates that there was low variation in participants' perceived enjoyment that the use of VR applications makes them feel good.

The mean value (Mobile Self-Efficacy [I could complete a job or task using a mobile device.]) is 3.89, which indicates that on average participants agree that they could complete a job or task using a mobile device. The standard deviation value is .759, which indicates that there was low variation in participants' mobile self-efficacy that they could complete a job or task using a mobile device.

The mean value (Mobile Self-Efficacy [I could complete a job or task using a mobile device if someone showed me how to do it.]) is 4.40, which indicates that on average participants strongly agree that they could complete a job or task using a mobile device if someone showed them how to do it. The standard deviation value is .681, which indicates that there was low variation in participants' mobile self-efficacy that they could complete a job or task using a mobile device if someone showed them how to do it.

The mean value (Mobile Self-Efficacy [I was fully able to use a mobile device before I began using VR applications.]) is 3.85, which indicates that on average participants agree that they were fully able to use a mobile device before they began using VR applications. The standard deviation value is 1.021, which indicates that there was high variation in participants' mobile self-efficacy that they were fully able to use a mobile device before they began using VR applications.

The mean value (Mobile Self-Efficacy [I am confident that I can effectively use VR applications using mobile technology.]) is 3.49, which indicates that on average participants agree that they are confident that they can effectively use VR applications using mobile technology. The standard deviation value is .804, which indicates that there was low variation in participants' mobile self-efficacy that they are confident that they can effectively use VR applications using mobile technology.

The mean value (Mobile Self-Efficacy [I believe I can use VR applications using mobile technology even if I have never used a similar technology before.]) is 3.36, which indicates that on average participants agree that they believe they can use VR applications using mobile technology even if they have never used a similar technology before. The standard deviation value is 1.009, which indicates that there was high variation in participants' mobile self-efficacy that they believe they can use VR applications using mobile technology even if they have never used a similar technology before.

The following tables (Table 34, 35) show the mean and the standard deviation for the AR and VR variables respectively.

Table 34. Mean and Standard Deviation for the AR variables

Descriptive Statistics			
	N	Mean	Std. Deviation
Intention	47	4.05	.626
Attitude	47	4.31	.503
Perceived Ease of Use	47	3.72	.693

Perceived Usefulness	47	4.18	.555
Perceived Relative Advantage	47	3.95	.645
Facilitating Condition	47	3.51	.795
Perceived Enjoyment	47	4.48	.579
Mobile Self-Efficacy	47	3.77	.592

Table 35. Mean and Standard Deviation for the VR variables

Descriptive Statistics			
	N	Mean	Std. Deviation
Intention	47	4.04	.574
Attitude	47	4.42	.527
Perceived Ease of Use	47	3.88	.724
Perceived Usefulness	47	4.21	.571
Perceived Relative Advantage	47	4.03	.634
Facilitating Condition	47	3.45	.727
Perceived Enjoyment	47	4.56	.611
Mobile Self-Efficacy	47	3.80	.545

4.5. Descriptive Statistics of Spatial Presence in AR

Since 7-point Likert scale is an interval scale hence 1 – 1.86 means not at all. 1.86 – 2.72 means moderately low. 2.72 – 3.58 means slightly low. 3.58 – 4.44 means neutral. 4.44 – 5.3 means slightly high. 5.3 – 6.16 means moderately high. 6.16 – 7 means very much high. Table 36 shows mean and standard deviation for Spatial Presence in AR.

Table 36. Descriptive statistics for Spatial Presence in AR application

Question	N	Mean	Std. Deviation

C1. Spatial Presence (TPI-SP) [How much did it seem as if the virtual waves you were seeing were in the same place as you?]	47	5.47	1.457
C1. Spatial Presence (TPI-SP) [How much did it seem as if you could reach out and touch the virtual waves you were seeing?]	47	4.79	1.654
C1. Spatial Presence (TPI-SP) [How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way?]	47	2.68	1.990
C1. Spatial Presence (TPI-SP) [To what extent did you experience a sense of being among the virtual waves you have seen?]	47	4.70	1.743
C1. Spatial Presence (TPI-SP) [How often did you want to or try to touch a virtual wave that you saw?]	47	3.57	2.234
C1. Spatial Presence (TPI-SP) [How would you describe your experience: as if you were watching through a monitor or watching events in the real world?]	47	5.17	1.773

The mean value for (Spatial Presence (TPI-SP) [How much did it seem as if the virtual waves you were seeing were in the same place as you?]) is 5.47, which means that it seemed moderately high as if the virtual waves they were seeing were in the same place as they were. The standard deviation value is 1.457, which means that there is high variation in in user experience.

The mean value for (Spatial Presence (TPI-SP) [How much did it seem as if you could reach out and touch the virtual waves you were seeing?]) is 4.79, which means that if they could reach out and touch the virtual waves they were seeing was slightly high. The standard deviation value is 1.654, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way?]) is 2.68, which means that when the virtual waves seemed to be headed toward them want to move to get out of its way was moderately low. The standard deviation value is 1.990, which means that there is high variation.

The mean value for (Spatial Presence (TPI-SP) [To what extent did you experience a sense of being among the virtual waves you have seen?]) is 4.70, which means that they experience a sense of being among the virtual waves at slightly high level. The standard deviation value is 1.743, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How often did you want to or try to touch a virtual wave that you saw?]) is 3.57, which means that they wanted try to touch a virtual wave slightly low. The standard deviation value is 2.234, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How would you describe your experience: as if you were watching through a monitor or watching events in the real world?]) is 5.17, which means that they were watching virtual waves slightly high through a monitor or watching events in the real world. The standard deviation value is 1.773, which means that there is high variation in user experience.

4.6. DESCTIPTIVE STATISTICS OF SPATIAL PRESENCE IN VR

Table 37 shows the mean and standard deviation for Spatial Presence in VR.

Table 37. Descriptive statistics for Spatial Presence in VR application

Question	N	Mean	Std. Deviation
Spatial Presence (TPI-SP) [How much did it seem as if the virtual waves you were seeing were in the same place as you?]	47	6.53	.687
Spatial Presence (TPI-SP) [How much did it seem as if you could reach out and touch the virtual waves you were seeing?]	47	6.00	1.615
Spatial Presence (TPI-SP) [How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way?]	47	3.98	2.131
Spatial Presence (TPI-SP) [To what extent did you experience a sense of being among the virtual waves you have seen?]	47	6.04	1.062

Spatial Presence (TPI-SP) [How often did you want to or try to touch a virtual wave that you saw?]	47	4.81	1.825
Spatial Presence (TPI-SP) [How would you describe your experience: as if you were watching through a monitor or watching events in the real world?]	47	5.83	1.698

The mean value for (Spatial Presence (TPI-SP) [How much did it seem as if the virtual waves you were seeing were in the same place as you?]) is 6.53, which means that it seemed very much high as if the virtual waves they were seeing were in the same place as they were. The standard deviation value is .687, which means that there is low variation in in user experience.

The mean value for (Spatial Presence (TPI-SP) [How much did it seem as if you could reach out and touch the virtual waves you were seeing?]) is 6.00, which means that if they could reach out and touch the virtual waves they were seeing was moderately high. The standard deviation value is 1.615, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way?]) is 3.98, which means that when the virtual waves seemed to be headed toward them want to move to get out of its way was neutral. The standard deviation value is 2.131, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [To what extent did you experience a sense of being among the virtual waves you have seen?]) is 6.04, which means that they experience a sense of being among the virtual waves at moderately high level. The standard deviation value is 1.062, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How often did you want to or try to touch a virtual wave that you saw?]) is 4.81, which means that they try to touch a virtual wave slightly low. The standard deviation value is 1.825, which means that there is high variation in user experience.

The mean value for (Spatial Presence (TPI-SP) [How would you describe your experience: as if you were watching through a monitor or watching events in the real world?]) is 5.83, which means that they were watching virtual waves moderately high through a monitor or watching events in the real world. The standard deviation value is 1.698, which means that there is high variation in user experience.

4.7. Descriptive Statistics about Sickness in AR

A 4point-Likert scale is an interval scale. Hence 0 – .8 means None, .8 – 1.6 means slight. 1.6 – 2.4 means moderate. 2.4 – 3.2 means high. 3.2 – 4 means severe.

Table 38 shows the mean and standard deviation for sickness in AR.

Table 38. Descriptive statistics for Sickness in AR application

Question	N	Mean	Std. Deviation
C2. Sickness (SSQ) [General Discomfort]	47	.11	.312
C2. Sickness (SSQ) [Fatigue]	47	.04	.204
C2. Sickness (SSQ) [Headache]	47	.11	.312
C2. Sickness (SSQ) [Eyestrain]	47	.40	.648
C2. Sickness (SSQ) [Difficulty Focusing]	47	.19	.495
C2. Sickness (SSQ) [Salivation Increasing]	47	.13	.741
C2. Sickness (SSQ) [Sweating]	47	.02	.146
C2. Sickness (SSQ) [Nausea]	47	.04	.204
C2. Sickness (SSQ) [Difficulty Concentrating]	47	.04	.204
C2. Sickness (SSQ) [Fullness of the Head]	47	.26	.488
C2. Sickness (SSQ) [Blurred Vision]	47	.19	.537
C2. Sickness (SSQ) [Dizziness with Eyes Open]	47	.11	.312
C2. Sickness (SSQ) [Dizziness with Eyes Closed]	47	.00	.000
C2. Sickness (SSQ) [Vertigo]	47	.00	.000
C2. Sickness (SSQ) [Stomach Awareness]	47	.02	.146
C2. Sickness (SSQ) [Burbing]	47	.00	.000

As we can see in Table 38, the mean values of all the variables of the sickness section are very low regarding AR.

4.8. DESCRIPTIVE STATISTICS ABOUT SICKNESS IN VR

Table 39 shows the mean and standard deviation for sickness in VR.

Table 39. Descriptive statistics for Sickness in VR application.

Question	N	Mean	Std. Deviation
Sickness (SSQ) [General Discomfort]	47	.38	.677
Sickness (SSQ) [Fatigue]	47	.13	.397
Sickness (SSQ) [Headache]	47	.11	.312
Sickness (SSQ) [Eyestrain]	47	.51	.718
Sickness (SSQ) [Difficulty Focusing]	47	.45	.904
Sickness (SSQ) [Salivation Increasing]	47	.02	.146
Sickness (SSQ) [Sweating]	47	.04	.204
Sickness (SSQ) [Nausea]	47	.04	.204
Sickness (SSQ) [Difficulty Concentrating]	47	.09	.351
Sickness (SSQ) [Fullness of the Head]	47	.43	.715
Sickness (SSQ) [Blurred Vision]	47	.40	.577
Sickness (SSQ) [Dizziness with Eyes Open]	47	.15	.465
Sickness (SSQ) [Dizziness with Eyes Closed]	47	.02	.146
Sickness (SSQ) [Vertigo]	47	.02	.146
Sickness (SSQ) [Stomach Awareness]	47	.06	.323
Sickness (SSQ) [Burbing]	47	.00	.000

As we can see in Table 39, the mean values of all the variables of the sickness section are very low regarding VR.

4.9. SPEARMAN CORRELATIONS

Spearman correlations were performed for examining statistically significant relationships between the eight variables of the second part of the AR and VR questionnaire.

AR questionnaire

The following hypotheses were tested:

H1a. Perceived ease of use (PEOU) has a positive effect on perceived usefulness (PU).

H1b. Perceived ease of use (PEOU) has a positive effect on attitude (Att).

H2a. Perceived usefulness (PU) has a positive effect on intention (I).

H2b. Perceived usefulness (PU) has a positive effect on attitude (Att).

H3a. Perceived enjoyment (PE) has a positive effect on attitude (Att).

H3b. Perceived enjoyment (PE) has a positive effect on perceived usefulness (PU).

H4. Attitude (Att) has a positive effect on intention (I).

H5a. Facilitating conditions (FC) has a positive effect on intention (I).

H5b. Facilitating conditions (FC) have a positive effect on perceived ease of use (PEOU).

H6. Perceived relative advantage (PRA) has a positive effect on perceived usefulness (PU).

Table 40 shows the correlations between all the variables of the second part of the AR questionnaire.

Table 40. Spearman correlations between the variables Intention, Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived Enjoyment and Mobile Self-Efficacy of the AR questionnaire

Correlations										
			Intent	Attitude	PEOU	PU	PRA	Facilitating Conditions	Perceived Enjoyment	Mobile Self-Efficacy
Spearman's rho	Intent	Correlation Coefficient	1.000	.610**	.393**	.550**	.472**	.489**	.369*	.382**
		Sig. (2-tailed)	.	.000	.006	.000	.001	.000	.011	.008
		N	47	47	47	47	47	47	47	47
	Attitude	Correlation Coefficient			.656**	.648**	.628**	.545**	.639**	.534**
		Sig. (2-tailed)			.000	.000	.000	.000	.000	.000
	PEOU	Correlation Coefficient				.562**	.421**	.602**	.496**	.597**
		Sig. (2-tailed)				.000	.003	.000	.000	.000
	PU	Correlation Coefficient					.634**	.455**	.494**	.402**
		Sig. (2-tailed)					.000	.001	.000	.005
	PRA	Correlation Coefficient						.393**	.612**	.303*
		Sig. (2-tailed)						.006	.000	.038
	Facilitating Conditions	Correlation Coefficient							.459**	.637**
		Sig. (2-tailed)							.001	.000

	Perceived Enjoyment	Correlation Coefficient								.463**
		Sig. (2-tailed)								.001
	Mobile Self-Efficacy	Correlation Coefficient								
		Sig. (2-tailed)								
**. Correlation is significant at the 0.01 level (2-tailed).										
*. Correlation is significant at the 0.05 level (2-tailed).										

The value of Spearman Correlation for Intention and Attitude is .610, the value of Spearman Correlation for Intention and PEOU is .393, the value of Spearman Correlation for Intention and Perceived Usefulness is .550, the value of Spearman Correlation for Intention and Perceived Relative Advantage is .472, the value of Spearman Correlation for Intention and Facilitating Conditions is .489, the value of Spearman Correlation for Intention and Perceived Enjoyment is .369, and the value of Spearman Correlation for Intention and Mobile Self-Efficacy is .534.

The value of Spearman Correlation for Attitude and PEOU is .656, the value of Spearman Correlation for Attitude and Perceived Usefulness is .648, the value of Spearman Correlation for Attitude and Perceived Relative Advantage is .628, the value of Spearman Correlation for Attitude and Facilitating Conditions is .545, the value of Spearman Correlation for Attitude and Perceived Enjoyment is .639, and the value of Spearman Correlation for Attitude and Mobile Self-Efficacy is .534.

The value of Spearman Correlation for PEOU and Perceived Usefulness is .562, the value of Spearman Correlation for PEOU and Perceived Relative Advantage is .421, the value of Spearman Correlation for PEOU and Facilitating Conditions is .602, the value of Spearman Correlation for PEOU and Perceived Enjoyment is .496, and the value of Spearman Correlation for PEOU and Mobile Self-Efficacy .597.

The value of Spearman Correlation for Perceived Usefulness and Perceived Relative Advantage is .634, the value of Spearman Correlation for Perceived Usefulness and Facilitating Conditions is .455, the value of Spearman Correlation for Perceived Usefulness and Perceived Enjoyment is .494, and the value of Spearman Correlation for Perceived Usefulness and Mobile Self-Efficacy is .402.

The value of Spearman Correlation for Perceived Relative Advantage and Facilitating Conditions is .393, the value of Spearman Correlation for Perceived Relative Advantage and Perceived Enjoyment is .612, and the value of Spearman Correlation for Perceived Relative Advantage and Mobile Self-Efficacy is .303.

The value of Spearman Correlation for Facilitating Conditions and Perceived Enjoyment is .459, and value of Spearman Correlation for Facilitating Conditions and Mobile Self-Efficacy is .637.

The value of Spearman Correlation for Perceived Enjoyment and Mobile Self-Efficacy is .463.

We can see that Spearman Correlation values for all above variables are positive, which indicates a positive effect of all above mentioned variables on each other (Figure 43).

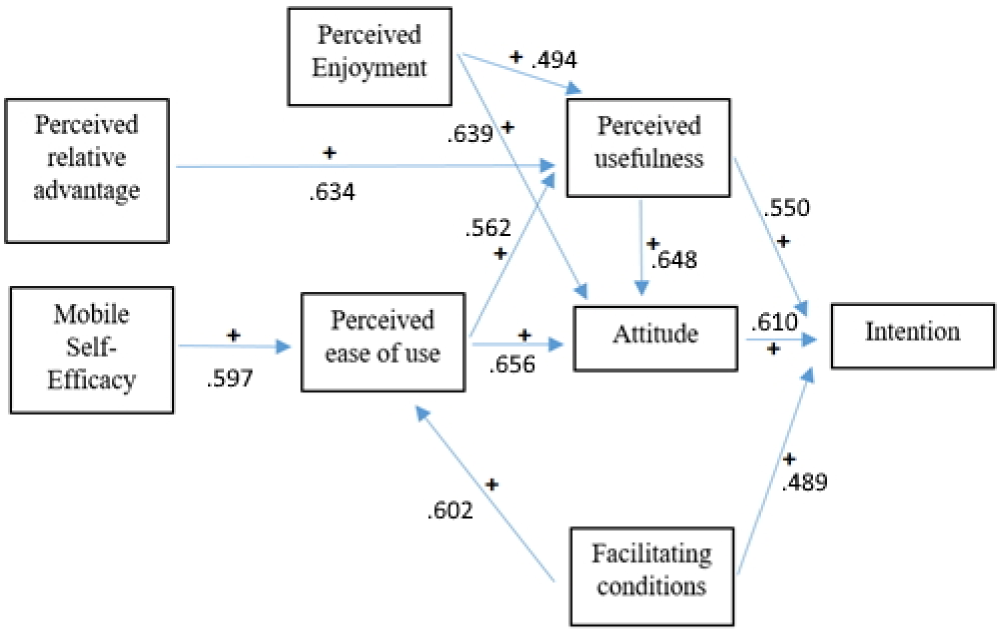

Figure 43. Correlations between the variables of the second part of the AR questionnaire

VR questionnaire

The following hypotheses were tested:

H1a. Perceived ease of use (PEOU) has a positive effect on perceived usefulness (PU).

H1b. Perceived ease of use (PEOU) has a positive effect on attitude (Att).

H2a. Perceived usefulness (PU) has a positive effect on intention (I).

H2b. Perceived usefulness (PU) has a positive effect on attitude (Att).

H3a. Perceived enjoyment (PE) has a positive effect on attitude (Att).

H3b. Perceived enjoyment (PE) has a positive effect on perceived usefulness (PU).

H4. Attitude (Att) has a positive effect on intention (I).

H5a. Facilitating conditions (FC) has a positive effect on intention (I).

H5b. Facilitating conditions (FC) have a positive effect on perceived ease of use (PEOU).

H6. Perceived relative advantage (PRA) has a positive effect on perceived usefulness (PU).

Table 41 shows the correlations between all the variables of the second part of the VR questionnaire.

Table 41. Spearman correlations between the variables Intention, Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived Enjoyment and Mobile Self-Efficacy of the VR questionnaire

Correlations										
			Intention	Attitude	PEOU	PU	PRA	Facilitating Conditions	Perceived Enjoyment	Mobile Self-Efficacy
Spearman's rho	Intention	Correlation Coefficient	1.000	.575**	.450**	.611**	.571**	.276	.388**	.225
		Sig. (2-tailed)	.	.000	.002	.000	.000	.061	.007	.128
		N	47	47	47	47	47	47	47	47
	Attitude	Correlation Coefficient			.409**	.519**	.569**	.121	.681**	.328*
		Sig. (2-tailed)			.004	.000	.000	.417	.000	.024
	PEOU	Correlation Coefficient				.422**	.435**	.338*	.298*	.649**
		Sig. (2-tailed)				.003	.002	.020	.042	.000
	PU	Correlation Coefficient					.625**	.086	.255	.347*
		Sig. (2-tailed)					.000	.567	.084	.017
	PRA	Correlation Coefficient						-.008	.539**	.344*

		Sig. (2-tailed)						.960	.000	.018
	Facilitating Conditions	Correlation Coefficient							**-.023**	**.213**
		Sig. (2-tailed)							.877	.150
	Perceived Enjoyment	Correlation Coefficient								**.309***
		Sig. (2-tailed)								.034
	Mobile Self-Efficacy	Correlation Coefficient								
		Sig. (2-tailed)								
**. Correlation is significant at the 0.01 level (2-tailed).										
*. Correlation is significant at the 0.05 level (2-tailed).										

The value of Spearman Correlation for Intention and Attitude is .575, the value of Spearman Correlation for Intention and PEOU is .450, the value of Spearman Correlation for Intention and Perceived Usefulness is .611, the value of Spearman Correlation for Intention and Perceived Relative Advantage is .571, the value of Spearman Correlation for Intention and Facilitating Conditions is .276, the value of Spearman Correlation for Intention and Perceived Enjoyment is .388, and the value of Spearman Correlation for Intention and Mobile Self-Efficacy is .255.

The value of Spearman Correlation for Attitude and PEOU is .409, the value of Spearman Correlation for Attitude and Perceived Usefulness is .519, the value of Spearman Correlation for Attitude and Perceived Relative Advantage is .569, the value of Spearman Correlation for Attitude and Facilitating Conditions is .121, the value of Spearman Correlation for Attitude and Perceived Enjoyment is .681, and the value of Spearman Correlation for Attitude and Mobile Self-Efficacy is .328.

The value of Spearman Correlation for PEOU and Perceived Usefulness is .422, the value of Spearman Correlation for PEOU and Perceived Relative Advantage is .435, the value of Spearman Correlation for PEOU and Facilitating Conditions is .338, the value of Spearman Correlation for PEOU and Perceived Enjoyment is .298, and the value of Spearman Correlation for PEOU and Mobile Self-Efficacy .649.

The value of Spearman Correlation for Perceived Usefulness and Perceived Relative Advantage is .625, the value of Spearman Correlation for Perceived Usefulness and Facilitating Conditions is .086, the value of Spearman Correlation for Perceived Usefulness and Perceived Enjoyment is .255, and the value of Spearman Correlation for Perceived Usefulness and Mobile Self-Efficacy is .347.

The value of Spearman Correlation for Perceived Relative Advantage and Facilitating Conditions is -.008, the value of Spearman Correlation for Perceived Relative Advantage and Perceived Enjoyment is .539, and the value of Spearman Correlation for Perceived Relative Advantage and Mobile Self-Efficacy is .344.

The value of Spearman Correlation for Facilitating Conditions and Perceived Enjoyment is -.023, and value of Spearman Correlation for Facilitating Conditions and Mobile Self-Efficacy is .213.

The value of Spearman Correlation for Perceived Enjoyment and Mobile Self-Efficacy is .309.

We can see that Spearman Correlation values for all above variables (except 1. Perceived Relative Advantage and Facilitating Conditions, 2. Facilitating Conditions and Perceived Enjoyment) are positive (figure 44), which indicates a positive effect of all above mentioned variables on each other.

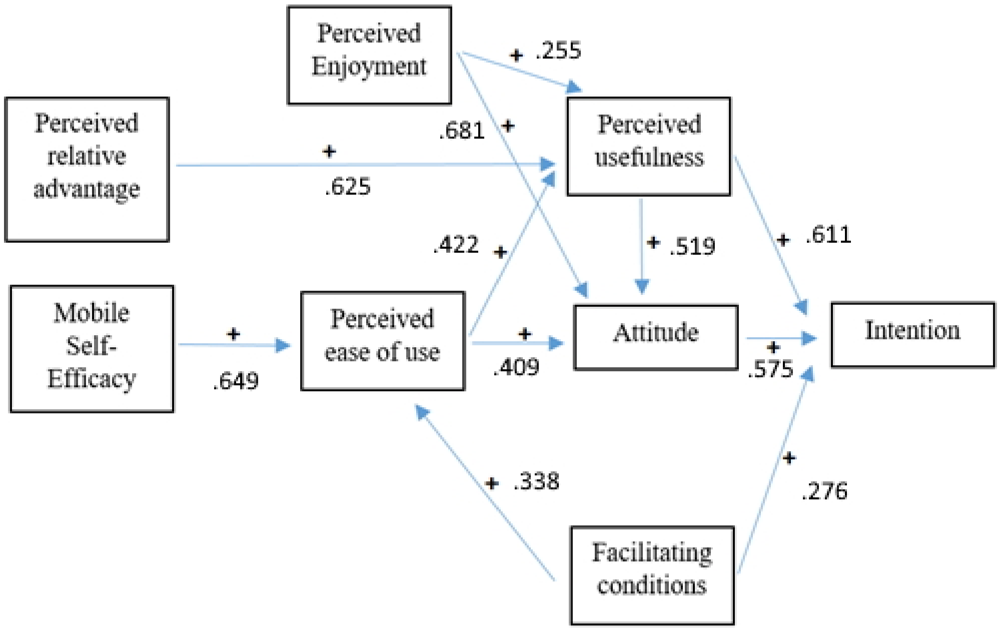

Figure 44. Correlations between the variables of the second part of the VR questionnaire

4.10. COMPARING VARIABLES OF AR AND VR (ANOVA)

One-way analysis of variance (one-way ANOVA) is a technique that can be used to compare whether two sample means are significantly different or not. ANOVA can be used to compare two or more groups (Conelly, 2021; Emerson, 2017; Wilcox, 2002).

We will use ANOVA in this section to compare the means regarding Augmented Reality and Virtual Reality.

The Hypothesis will be:

H0: $\mu1 = \mu2$

HA: $\mu1 \neq \mu2$

While:

$\mu1$ = mean regarding AR

$\mu2$ = mean regarding VR

In order to apply ANOVA, the data must be normally distributed (Rutherford, 2001). As mentioned in the section 4.1 of the current chapter, after the Kolmogorov Smirnov normality test was applied on all variables of the AR and VR questionnaire to test the normality of the variables, the results showed that the variables were not normally distributed. In order to apply ANOVA, the variables were normalized using the test = $(x-\mu)/\sigma$, where μ = mean, and σ = standard deviation.

In addition, the following assumptions regarding ANOVA are also satisfied:

- The samples were randomly selected for both groups, the Augmented Reality and the Virtual Reality.
- The sample size of both groups i.e., the Augmented Reality and the Virtual Reality is the same.
- There were no outliers in the dataset.
- The scores in both groups i.e., the Augmented Reality and the Virtual Reality were independent of each other.

(Rutherford, 2001)

Comparing Intention for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I intend to use AR applications in my future teaching

μ_2 = I intend to use VR applications in my future teaching

Level of Significance = .05

Table 42 shows the ANOVA for the variable of Intention of the AR and VR questionnaire "I intent to use AR/VR applications in my future teaching".

Table 42. ANOVA for the variable of Intention of the AR and VR questionnaire "I intent to use AR/VR applications in my future teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.726	2	1.363	4.379	.018
Within Groups	13.699	44	.311		
Total	16.426	46			

Since F = 4.379 and p-value < .05 (here it is .018), we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I plan to use AR applications in my future teaching

μ_2 = I plan to use VR applications in my future teaching

Level of Significance = .05

Table 43 shows the ANOVA for the variable of Intention of the AR and VR questionnaire "I plan to use AR/VR applications in my future teaching".

Table 43. ANOVA for the variable of Intention of the AR and VR questionnaire "I plan to use AR/VR applications in my future teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.753	2	3.377	6.685	.003
Within Groups	22.225	44	.505		
Total	28.979	46			

Since $F = 3.377$ and p-value $< .05$ (here it is .003) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I predict I would use AR applications in my future teaching

μ_2 = I predict I would use VR applications in my future teaching

Level of Significance = .05

Table 44 shows the ANOVA for the variable of Intention of the AR and VR questionnaire "I predict I would use AR/VR applications in my future teaching".

Table 44. ANOVA for the variable Intention of the AR and VR questionnaire "I predict I would use AR/VR applications in my future teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.714	2	3.357	6.130	.004
Within Groups	24.095	44	.548		
Total	30.809	46			

Since $F = 6.130$ and p-value $< .05$ (here it is .004) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Comparing Attitude for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Using AR applications is a good idea

μ_2 = Using VR applications is a good idea

Level of Significance = .05

Table 45 shows the ANOVA for the variable of Attitude of the AR and VR questionnaire "Using AR/VR applications is a good idea".

Table 45. ANOVA for the variable Attitude of the AR and VR questionnaire "Using AR/VR applications is a good idea"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.047	2	1.024	4.707	.014
Within Groups	9.570	44	.217		
Total	11.617	46			

Since F = 4.707 and p-value < .05 (here it is .014) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I like using AR applications

μ_2 = I like using VR applications

Level of Significance = .05

Table 46 shows the ANOVA for the variable of Attitude of the AR and VR questionnaire "I like using AR/VR applications".

Table 46. ANOVA for the variable Attitude of the AR and VR questionnaire "I like using AR/VR applications"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.712	3	2.571	6.294	.001
Within Groups	17.564	43	.408		
Total	25.277	46			

Since F = 6.294 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = It is desirable to use AR applications

μ_2 = It is desirable to use VR applications

Level of Significance = .05

Table 47 shows the ANOVA for the variable of Attitude of the AR and VR questionnaire "It is desirable to use AR/VR applications".

Table 47. ANOVA for the variable Attitude of the AR and VR questionnaire "It is desirable to use AR/VR applications"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.774	2	.387	1.304	.282
Within Groups	13.056	44	.297		
Total	13.830	46			

Since F = 1.304 and p-value > .05 (here it is .282) we do not reject our H_0 and conclude that $\mu_1 = \mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived ease of use for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = My interaction with AR applications is clear and understandable

μ_2 = My interaction with VR applications is clear and understandable

Level of Significance = .05

Table 48 shows the ANOVA for the variable of Perceived ease of use of the AR and VR questionnaire "My interaction with AR/VR applications is clear and understandable".

Table 48. ANOVA for the variable Perceived ease of use of the AR and VR questionnaire "My interaction with AR/VR applications is clear and understandable"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.793	3	1.931	4.016	.013
Within Groups	20.675	43	.481		
Total	26.468	46			

Since F = 4.016 and p-value < .05 (here it is .013) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = It is easy for me to become skillful at using AR applications

μ_2 = It is easy for me to become skillful at using VR applications

Level of Significance = .05

Table 49 shows the ANOVA for the variable of Perceived ease of use of the AR and VR questionnaire “It is easy for me to become skillful at using AR/VR applications”.

Table 49. ANOVA for the variable Perceived ease of use of the AR and VR questionnaire “It is easy for me to become skillful at using AR/VR applications”

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.367	3	3.789	7.962	.000
Within Groups	20.463	43	.476		
Total	31.830	46			

Since F = 7.962 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I find AR applications easy to use

μ_2 = I find VR applications easy to use

Level of Significance = .05

Table 50 shows the ANOVA for the variable of Perceived ease of use of the AR and VR questionnaire “I find AR/VR applications easy to use”.

Table 50. ANOVA for the variable Perceived ease of use of the AR and VR questionnaire “I find AR/VR applications easy to use”

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.347	3	4.449	8.640	.000
Within Groups	22.142	43	.515		
Total	35.489	46			

Since F = 8.640 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived usefulness for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Using AR applications enhances my teaching effectiveness

μ_2 = Using VR applications enhances my teaching effectiveness

Level of Significance = .05

Table 51 shows the ANOVA for the variable of Perceived usefulness of the AR and VR questionnaire "Using AR/VR applications enhances my teaching effectiveness".

Table 51. ANOVA for the variable Perceived usefulness of the AR and VR questionnaire "Using AR/VR applications enhances my teaching effectiveness"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.519	2	1.759	6.289	.004
Within Groups	12.311	44	.280		
Total	15.830	46			

Since F = 6.289 and p-value < .05 (here it is .004) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = AR applications are useful for my teaching

μ_2 = VR applications are useful for my teaching

Level of Significance = .05

Table 52 shows the ANOVA for the variable of Perceived usefulness of the AR and VR questionnaire "AR/VR applications are useful for my teaching".

Table 52. ANOVA for the variable Perceived usefulness of the AR and VR questionnaire "AR/VR applications are useful for my teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.051	3	.684	2.368	.084
Within Groups	12.417	43	.289		
Total	14.468	46			

Since F = 2.368 and p-value > .05 (here it is .084) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Using AR applications increases my teaching productivity

μ_2 = Using VR applications increases my teaching productivity

Level of Significance = .05

Table 53 shows the ANOVA for the variable of Perceived usefulness of the AR and VR questionnaire "Using AR/VR applications increases my teaching productivity".

Table 53. ANOVA for the variable Perceived usefulness of the AR and VR questionnaire "Using AR/VR applications increases my teaching productivity"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.407	2	1.203	2.709	.078
Within Groups	19.550	44	.444		
Total	21.957	46			

Since F = 2.709 and p-value > .05 (here it is .078) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived relative advantage for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = AR applications would be more advantageous in my teaching than other technologies

μ_2 = VR applications would be more advantageous in my teaching than other technologies

Level of Significance = .05

Table 54 shows the ANOVA for the variable of Perceived relative advantage of the AR and VR questionnaire "AR/VR applications would be more advantageous in my teaching than other technologies".

Table 54. ANOVA for the variable Perceived relative advantage of the AR and VR questionnaire "AR/VR applications would be more advantageous in my teaching than other technologies"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.223	3	3.741	9.060	.000
Within Groups	17.756	43	.413		
Total	28.979	46			

Since $F = 9.060$ and p-value $< .05$ (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = AR applications would make my teaching more effective than other technologies

μ_2 = VR applications would make my teaching more effective than other technologies

Level of Significance = .05

Table 55 shows the ANOVA for the variable of Perceived relative advantage of the AR and VR questionnaire "AR/VR applications would make my teaching more effective than other technologies".

Table 55. ANOVA for the variable Perceived relative advantage of the AR and VR questionnaire "AR/VR applications would make my teaching more effective than other technologies"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.339	3	1.446	2.976	.042
Within Groups	20.895	43	.486		
Total	25.234	46			

Since $F = 2.976$ and p-value $< .05$ (here it is .042) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = AR applications are relatively efficient in my teaching compared to existing technologies

μ_2 = VR applications are relatively efficient in my teaching compared to existing technologies

Level of Significance = .05

Table 56 shows the ANOVA for the variable of Perceived relative advantage of the AR and VR questionnaire "AR/VR applications are relatively efficient in my teaching compared to existing technologies".

Table 56. ANOVA for the variable Perceived relative advantage of the AR and VR questionnaire "AR/VR applications are relatively efficient in my teaching compared to existing technologies"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.902	3	2.634	6.274	.001
Within Groups	18.055	43	.420		
Total	25.957	46			

Since F = 6.274 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = The use of AR applications offers new learning opportunities compared to existing technologies

μ_2 = The use of VR applications offers new learning opportunities compared to existing technologies

Level of Significance = .05

Table 57 shows the ANOVA for the variable of Perceived relative advantage of the AR and VR questionnaire "The use of AR/VR applications offers new learning opportunities compared to existing technologies".

Table 57. ANOVA for the variable Perceived relative advantage of the AR and VR questionnaire "The use of AR/VR applications offers new learning opportunities compared to existing technologies"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.172	3	1.391	2.234	.098
Within Groups	26.764	43	.622		
Total	30.936	46			

Since F = 2.234 and p-value > .05 (here it is .098) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Overall, AR applications are better than existing technologies

μ_2 = Overall, VR applications are better than existing technologies

Level of Significance = .05

Table 58 shows the ANOVA for the variable of Perceived relative advantage of the AR and VR questionnaire "Overall, AR/VR applications are better than existing technologies".

Table 58. ANOVA for the variable Perceived relative advantage of the AR and VR questionnaire "Overall, AR/VR applications are better than existing technologies"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	18.575	3	6.192	15.392	.000
Within Groups	17.298	43	.402		
Total	35.872	46			

Since F = 15.392 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Comparing Facilitating conditions for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I have the resources (e.g., Internet connection, tablets) necessary to use AR applications in my teaching

μ_2 = I have the resources (e.g., Internet connection, tablets) necessary to use VR applications in my teaching

Level of Significance = .05

Table 59 shows the ANOVA for the variable of Facilitating conditions of the AR and VR questionnaire "I have the resources (e.g., Internet connection, tablets) necessary to use AR/VR applications in my teaching".

Table 59. ANOVA for the variable Facilitating conditions of the AR and VR questionnaire "I have the resources (e.g., Internet connection, tablets) necessary to use AR/VR applications in my teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.390	3	2.463	2.232	.098
Within Groups	47.461	43	1.104		
Total	54.851	46			

Since F = 2.232 and p-value > .05 (here it is .098) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I have the knowledge needed to use AR applications in my teaching

μ_2 = I have the knowledge needed to use VR applications in my teaching

Level of Significance = .05

Table 60 shows the ANOVA for the variable of Facilitating conditions of the AR and VR questionnaire "I have the knowledge needed to use AR/VR applications in my teaching".

Table 60. ANOVA for the variable Facilitating conditions of the AR and VR questionnaire "I have the knowledge needed to use AR/VR applications in my teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.947	3	1.316	1.369	.265
Within Groups	41.329	43	.961		
Total	45.277	46			

Since F = 1.369 and p-value > .05 (here it is .265) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I have the time needed to use AR applications in my teaching

μ_2 = I have the time needed to use VR applications in my teaching

Level of Significance = .05

Table 61 shows the ANOVA for the variable of Facilitating conditions of the AR and VR questionnaire "I have the time needed to use AR/VR applications in my teaching".

Table 61. ANOVA for the variable Facilitating conditions of the AR and VR questionnaire "I have the time needed to use AR/VR applications in my teaching"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.780	3	4.927	8.457	.000
Within Groups	25.050	43	.583		
Total	39.830	46			

Since F = 8.457 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived enjoyment for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Using AR applications is truly fun

μ_2 = Using VR applications is truly fun

Level of Significance = .05

Table 62 shows the ANOVA for the variable of Perceived enjoyment of the AR and VR questionnaire "Using AR/VR applications is truly fun".

Table 62. ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire "Using AR/VR applications is truly fun"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.467	2	.734	2.774	.073
Within Groups	11.639	44	.265		
Total	13.106	46			

Since F = 2.774 and p-value > .05 (here it is .073) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I know using AR applications to be enjoyable

μ_2 = I know using VR applications to be enjoyable

Level of Significance = .05

Table 63 shows the ANOVA for the variable of Perceived enjoyment of the AR and VR questionnaire "I know using AR/VR applications to be enjoyable".

Table 63. ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire "I know using AR/VR applications to be enjoyable"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.450	2	.725	2.605	.085
Within Groups	12.252	44	.278		
Total	13.702	46			

Since F = 2.605 and p-value > .05 (here it is .085) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = The use of AR applications gives me pleasure

μ_2 = The use of VR applications gives me pleasure

Level of Significance = .05

Table 64 shows the ANOVA for the variable of Perceived enjoyment of the AR and VR questionnaire “The use of AR/VR applications gives me pleasure”.

Table 64. ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire “The use of AR/VR applications gives me pleasure”

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.525	3	3.508	8.893	.000
Within Groups	16.964	43	.395		
Total	27.489	46			

Since F = 8.893 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = The use of AR applications makes me feel good

μ_2 = The use of VR applications makes me feel good

Level of Significance = .05

Table 65 shows the ANOVA for the variable of Perceived enjoyment of the AR and VR questionnaire "The use of AR/VR applications makes me feel good".

Table 65. ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire "The use of AR/VR applications makes me feel good"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.839	3	3.613	7.763	.000
Within Groups	20.012	43	.465		
Total	30.851	46			

Since F = 7.763 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Comparing Mobile Self-Efficacy for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I was fully able to use a mobile device before I began using AR applications

μ_2 = I was fully able to use a mobile device before I began using VR applications

Level of Significance = .05

Table 66 shows the ANOVA for the variable of Mobile Self-Efficacy of the AR and VR questionnaire "I was fully able to use a mobile device before I began using AR/VR applications".

Table 66. ANOVA for the variable Mobile Self-Efficacy of the AR and VR questionnaire "I was fully able to use a mobile device before I began using AR/VR applications"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	11.942	3	3.981	6.463	.001
Within Groups	26.484	43	.616		
Total	38.426	46			

Since F = 6.463 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I am confident that I can effectively use AR applications using mobile technology

μ_2 = I am confident that I can effectively use VR applications using mobile technology

Level of Significance = .05

Table 67 shows the ANOVA for the variable of Mobile Self-Efficacy of the AR and VR questionnaire "I am confident that I can effectively use AR/VR applications using mobile technology".

Table 67. ANOVA for the variable Mobile Self-Efficacy of the AR and VR questionnaire "I am confident that I can effectively use AR/VR applications using mobile technology"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.391	3	4.130	7.619	.000
Within Groups	23.311	43	.542		
Total	35.702	46			

Since F = 7.619 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = I believe I can use AR applications using mobile technology even if I have never used a similar technology before

μ_2 = I believe I can use VR applications using mobile technology even if I have never used a similar technology before

Level of Significance = .05

Table 68 shows the ANOVA for the variable of Mobile Self-Efficacy of the AR and VR questionnaire "I believe I can use AR/VR applications using mobile technology even if I have never used a similar technology before".

Table 68. ANOVA for the variable Mobile Self-Efficacy of the AR and VR questionnaire "I believe I can use AR/VR applications using mobile technology even if I have never used a similar technology before"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15.788	3	5.263	8.107	.000
Within Groups	27.914	43	.649		
Total	43.702	46			

Since F = 8.107 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2.

Now, we will compare the eight variables (using ANOVA) from the second part of the AR and VR questionnaire.

Comparing Intention for Augmented Reality and Virtual Reality:

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Intention in Augmented Reality

μ_2 = Intention in Virtual Reality

Level of Significance = .05

Table 69 shows the ANOVA for the variable Intention of the AR and VR questionnaire.

Table 69. ANOVA for the variable Intention of the AR and VR questionnaire

ANOVA					
Intent					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.612	6	.769	2.297	**.053**
Within Groups	13.383	40	.335		
Total	17.995	46			

Since F = 2.297 and p-value > .05 (here it is .053) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Attitude for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Attitude in Augmented Reality

μ_2 = Attitude in Virtual Reality

Level of Significance = .05

Table 70 shows the ANOVA for the variable Attitude of the AR and VR questionnaire.

Table 70. ANOVA for the variable Attitude of the AR and VR questionnaire

ANOVA					
Attitude					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.000	6	.500	2.313	**.052**
Within Groups	8.646	40	.216		

Total	11.645	46			

Since F = 2.313 and p-value > .05 (here it is .052) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived Ease of Use for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Perceived Ease of Use in Augmented Reality

μ_2 = Perceived Ease of Use in Virtual Reality

Level of Significance = .05

Table 71 shows the ANOVA for the variable Perceived ease of use of the AR and VR questionnaire.

Table 71. ANOVA for the variable Perceived ease of use of the AR and VR questionnaire

ANOVA					
PEOU					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.469	8	1.309	4.286	**.001**
Within Groups	11.602	38	.305		
Total	22.071	46			

Since F = 4.286 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Perceived ease of use in Virtual Reality is greater than the mean value of Perceived ease of use in Augmented Reality, we can say that Perceived ease of use in Virtual Reality is higher than Perceived ease of use in Augmented Reality.

Comparing Perceived Usefulness for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Perceived Usefulness in Augmented Reality

μ_2 = Perceived Usefulness in Virtual Reality

Level of Significance = .05

Table 72 shows the ANOVA for the variable Perceived usefulness of the AR and VR questionnaire.

Table 72. ANOVA for the variable Perceived usefulness of the AR and VR questionnaire

ANOVA					
PU					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.010	6	.668	2.629	**.030**
Within Groups	10.170	40	.254		
Total	14.180	46			

Since F = 2.629 and p-value < .05 (here it is .030) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Perceived usefulness in Virtual Reality is greater than the mean value of Perceived usefulness in Augmented Reality, we can say that Perceived usefulness in Virtual Reality is higher than Perceived usefulness in Augmented Reality.

Comparing Perceived Relative Advantage for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Perceived Relative Advantage in Augmented Reality

μ_2 = Perceived Relative Advantage in Virtual Reality

Level of Significance = .05

Table 73 shows the ANOVA for the variable Perceived Relative Advantage of the AR and VR questionnaire.

Table 73. ANOVA for the variable Perceived Relative Advantage of the AR and VR questionnaire

ANOVA					
Perceived Relative Advantage					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.741	11	.976	4.061	**.001**
Within Groups	8.416	35	.240		
Total	19.157	46			

Since F = 4.061 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Perceived Relative Advantage in Virtual Reality is greater than the mean value of Perceived Relative Advantage in Augmented Reality, we can say that Perceived Relative Advantage in Virtual Reality is higher than Perceived Relative Advantage in Augmented Reality.

Comparing Facilitating Conditions for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Facilitating Conditions in Augmented Reality

μ_2 = Facilitating Conditions in Virtual Reality

Level of Significance = .05

Table 74 shows the ANOVA for the variable Facilitating conditions of the AR and VR questionnaire.

Table 74. ANOVA for the variable Facilitating conditions of the AR and VR questionnaire

ANOVA					
Facilitating Conditions					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.891	9	.766	1.277	**.282**
Within Groups	22.187	37	.600		
Total	29.078	46			

Since F = 1.277 and p-value > .05 (here it is .0282) we do not reject our H_0 and conclude that μ_1=$\mu_{2,}$ which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Perceived Enjoyment for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Perceived Enjoyment in Augmented Reality

μ_2 = Perceived Enjoyment in Virtual Reality

Level of Significance = .05

Table 75 shows the ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire.

Table 75. ANOVA for the variable Perceived enjoyment of the AR and VR questionnaire

ANOVA
Perceived Enjoyment

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.575	8	.572	2.003	**.073**
Within Groups	10.851	38	.286		
Total	15.426	46			

Since F = 2.003 and p-value > .05 (here it is .073) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

Comparing Mobile Self-Efficacy for Augmented Reality and Virtual Reality

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Mobile Self-Efficacy in Augmented Reality

μ_2 = Mobile Self-Efficacy in Virtual Reality

Level of Significance = .05

Table 76 shows the ANOVA for the variable Mobile Self-Efficacy of the AR and VR questionnaire.

Table 76. ANOVA for the variable Mobile Self-Efficacy of the AR and VR questionnaire

ANOVA					
Mobile Self-Efficacy					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.949	9	1.105	6.644	.000
Within Groups	6.157	37	.166		
Total	16.106	46			

Since F = 6.644 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1\neq\mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Mobile Self-Efficacy in Virtual Reality is greater than the mean value of Mobile Self-Efficacy in Augmented Reality, we can say that Mobile Self-Efficacy in Virtual Reality is higher than Mobile Self-Efficacy in Augmented Reality.

4.11. Comparing Spatial Presence of AR and VR (ANOVA)

Now, we will use ANOVA to compare Spatial Presence between Augmented Reality and Virtual Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = How much did it seem as if the virtual waves you were seeing were in the same place as you (AR)

μ_2 = How much did it seem as if the virtual waves you were seeing were in the same place as you (VR)

Level of Significance = .05

Table 77 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How much did it seem as if the virtual waves you were seeing were in the same place as you".

Table 77. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How much did it seem as if the virtual waves you were seeing were in the same place as you"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.821	3	4.274	2.165	.106
Within Groups	84.882	43	1.974		
Total	97.702	46			

Since $F = 2.165$ and p-value > .05 (here it is .106) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = How much did it seem as if you could reach out and touch the virtual waves you were seeing? (AR)

μ_2 = How much did it seem as if you could reach out and touch the virtual waves you were seeing? (VR)

Level of Significance = .05

Table 78 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How much did it seem as if you could reach out and touch the virtual waves you were seeing".

Table 78. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How much did it seem as if you could reach out and touch the virtual waves you were seeing"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.808	5	4.962	2.013	.097
Within Groups	101.064	41	2.465		
Total	125.872	46			

Since $F = 2.013$ and p-value > .05 (here it is .097) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way? (AR)

μ_2 = How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way? (VR)

Level of Significance = .05

Table 79 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way".

Table 79. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	71.426	6	11.904	4.298	.002
Within Groups	110.786	40	2.770		
Total	182.213	46			

Since F = 4.298 and p-value < .05 (here it is .002) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of the question "How often when the virtual waves seemed to be headed toward you did you want to move to get out of its way" in Virtual Reality is greater than the mean value of the same question in Augmented Reality, we can say that the students felt more often when the virtual waves seemed to be headed toward them that they wanted to move to get out of its way in Virtual Reality than in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = To what extent did you experience a sense of being among the virtual waves you have seen? (AR)

μ_2 = To what extent did you experience a sense of being among the virtual waves you have seen (VR)

Level of Significance = .05

Table 80 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "To what extent did you experience a sense of being among the virtual waves you have seen".

Table 80. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "To what extent did you experience a sense of being among the virtual waves you have seen"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.718	4	5.179	1.826	.142
Within Groups	119.112	42	2.836		
Total	139.830	46			

Since F = 1.826 and p-value > .05 (here it is .142) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = How often did you want to or try to touch a virtual wave that you saw? (AR)

μ_2 = How often did you want to or try to touch a virtual wave that you saw seen (VR)

Level of Significance = .05

Table 81 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How often did you want to or try to touch a virtual wave that you saw".

Table 81. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How often did you want to or try to touch a virtual wave that you saw"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	74.281	6	12.380	3.191	.012
Within Groups	155.208	40	3.880		
Total	229.489	46			

Since F = 3.191 and p-value < .05 (here it is .012) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of the question "How often did you want to or try to touch a virtual wave that you saw" in Virtual Reality is greater than the mean value of the same question in Augmented Reality, we can say that the students felt more often that they wanted to try to touch a virtual wave that they saw in Virtual Reality than in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = How would you describe your experience: as if you were watching through a monitor or watching events in the real world? (AR)

μ_2 = How would you describe your experience: as if you were watching through a monitor or watching events in the real world? (VR)

Level of Significance = .05

Table 82 shows the ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How would you describe your experience: as if you were watching through a monitor or watching events in the real world".

Table 82. ANOVA for the variable Spatial Presence of the AR and VR questionnaire "How would you describe your experience: as if you were watching through a monitor or watching events in the real world"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	36.342	6	6.057	2.237	.059
Within Groups	108.297	40	2.707		
Total	144.638	46			

Since F = 2.237 and p-value > .05 (here it is .059) we do not reject our H_0 and conclude that $\mu_1=\mu_2$, which means that there is not a statistically significant difference between the mean of $\mu 1$ and $\mu 2$.

4.12. COMPARE SICKNESS BETWEEN AR AND VR

Now, we will use ANOVA to compare sickness between Augmented Reality and Virtual Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = General Discomfort due to AR

μ_2 = General Discomfort due to VR

Level of Significance = .05

Table 83 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "General Discomfort".

Table 83. ANOVA for the variable Sickness of the AR and VR questionnaire "General Discomfort"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.533	2	.266	2.979	.061
Within Groups	3.935	44	.089		
Total	4.468	46			

Since F = 2.979 and p-value > .05 (here it is .061) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Fatigue due to AR

μ_2 = Fatigue due to VR

Level of Significance = .05

Table 84 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Fatigue".

Table 84. ANOVA for the variable Sickness of the AR and VR questionnaire "Fatigue"

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.189	2	.094	2.405	.102
Within Groups	1.726	44	.039		
Total	1.915	46			

Since F = 2.405 and p-value > .05 (here it is .102) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of µ1 and µ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Headache due to AR

μ_2 = Headache due to VR

Level of Significance = .05

Table 85 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Headache".

Table 85. ANOVA for the variable Sickness of the AR and VR questionnaire "Headache"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.000	.988
Within Groups	19.319	45	.429		
Total	19.319	46			

Since F = .000 and p-value > .05 (here it is .988) we do not reject our H_0 and conclude that μ_1=μ_2, which means that there is not a statistically significant difference between the mean of µ1 and µ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Eyestrain due to AR

μ_2 = Eyestrain due to VR

Level of Significance = .05

Table 86 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Eyestrain".

Table 86. ANOVA for the variable Sickness of the AR and VR questionnaire "Eyestrain"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.629	2	4.315	17.760	.000
Within Groups	10.690	44	.243		
Total	19.319	46			

Since F = 17.760 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Eyestrain in Virtual Reality is greater than the mean value of Eyestrain in Augmented Reality, we can say that Eyestrain in Virtual Reality is higher than Eyestrain in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Difficulty Focusing due to AR

μ_2 = Difficulty Focusing due to VR

Level of Significance = .05

Table 87 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Difficulty Focusing".

Table 87. ANOVA for the variable Sickness of the AR and VR questionnaire "Difficulty Focusing"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.495	3	1.165	6.437	.001
Within Groups	7.782	43	.181		
Total	11.277	46			

Since F = 6.437 and p-value < .05 (here it is .001) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Difficulty Focusing in Virtual Reality is greater than the mean value of Difficulty Focusing in Augmented Reality, we can say that Difficulty Focusing in Virtual Reality is higher than Difficulty Focusing in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Salivation Increasing due to AR

μ_2 = Salivation Increasing due to VR

Level of Significance = .05

Table 88 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Salivation Increasing".

Table 88. ANOVA for the variable Sickness of the AR and VR questionnaire "Salivation Increasing"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.256	1	24.256	1115.766	.000
Within Groups	.978	45	.022		
Total	25.234	46			

Since F = 24.256 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Salivation Increasing in Augmented Reality is greater than the mean value of Salivation Increasing in Virtual Reality, we can say that Salivation Increasing in Augmented Reality is higher than Salivation Increasing in Virtual Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Sweating due to AR

μ_2 = Sweating due to VR

Level of Significance = .05

Table 89 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Sweating".

Table 89. ANOVA for the variable Sickness of the AR and VR questionnaire "Sweating"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.479	1	.479	43.085	.000
Within Groups	.500	45	.011		
Total	.979	46			

Since F = 43.085 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Sweating in Virtual Reality is greater than the mean value of Sweating in Augmented Reality, we can say that Sweating in Virtual Reality is higher than Sweating in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Nausea due to AR

μ_2 = Nausea due to VR

Level of Significance = .05

Table 90 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Nausea".

Table 90. ANOVA for the variable Sickness of the AR and VR questionnaire "Nausea"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.004	1	.004	.089	.767
Within Groups	1.911	45	.042		
Total	1.915	46			

Since F = .089 and p-value > .05 (here it is .767) we do not reject our H_0 and conclude that $\mu_1 = \mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Difficulty Concentrating due to AR

μ_2 = Difficulty Concentrating due to VR

Level of Significance = .05

Table 91 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Difficulty Concentrating".

Table 91. ANOVA for the variable Sickness of the AR and VR questionnaire "Difficulty Concentrating"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.938	2	.469	21.107	.000
Within Groups	.977	44	.022		
Total	1.915	46			

Since F = 21.107 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Difficulty Concentrating in Virtual Reality is greater than the mean value of Difficulty Concentrating in Augmented Reality, we can say that Difficulty Concentrating in Virtual Reality is higher than Difficulty Concentrating in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Fullness of the Head due to AR

μ_2 = Fullness of the Head due to VR

Level of Significance = .05

Table 92 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Fullness of the Head".

Table 92. ANOVA for the variable Sickness of the AR and VR questionnaire "Fullness of the Head"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.057	2	2.529	18.926	.000
Within Groups	5.879	44	.134		
Total	10.936	46			

Since F = 18.926 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Fullness of the Head in Virtual Reality is greater than the mean value of Fullness of the Head in Augmented Reality, we can say that Fullness of the Head in Virtual Reality is higher than Fullness of the Head in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Blurred Vision due to AR

μ_2 = Blurred Vision due to VR

Level of Significance = .05

Table 93 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Blurred Vision".

Table 93. ANOVA for the variable Sickness of the AR and VR questionnaire "Blurred Vision"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.977	2	1.988	9.407	.000
Within Groups	9.300	44	.211		
Total	13.277	46			

Since F = 9.407 and p-value < .05 (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Blurred Vision in Virtual Reality is greater than the mean value of Blurred Vision in Augmented Reality, we can say that Blurred Vision in Virtual Reality is higher than Blurred Vision in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where:

μ_1 = Dizziness with Eyes Open due to AR

μ_2 = Dizziness with Eyes Open to VR

Level of Significance = .05

Table 94 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Dizziness with Eyes Open".

Table 94. ANOVA for the variable Sickness of the AR and VR questionnaire "Dizziness with Eyes Open"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.897	2	.948	16.227	.000
Within Groups	2.571	44	.058		
Total	4.468	46			

Since $F = 16.227$ and p-value $< .05$ (here it is .000) we reject our H_0 and conclude that $\mu_1 \neq \mu_2$, which means that there is a statistically significant difference between the mean of μ1 and μ2. Since the mean value of Dizziness with Eyes Open in Virtual Reality is greater than the mean value of Dizziness with Eyes Open in Augmented Reality, we can say that Dizziness with Eyes Open in Virtual Reality is higher than Dizziness with Eyes Open in Augmented Reality.

The following hypotheses will be tested:

H_0: $\mu_1 \neq \mu_2$

H_A: $\mu_1 = \mu_2$

Where:

μ_1 = Stomach Awareness due to AR

μ_2 = Stomach Awareness due to VR

Level of Significance = .05

Table 95 shows the ANOVA for the variable Sickness of the AR and VR questionnaire "Stomach Awareness".

Table 95. ANOVA for the variable Sickness of the AR and VR questionnaire "Stomach Awareness"

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.001	2	.000	.021	.979
Within Groups	.978	44	.022		
Total	.979	46			

Since $F = .021$ and p-value $> .05$ (here it is .979) we do not reject our H_0 and conclude that $\mu_1 = \mu_2$, which means that there is not a statistically significant difference between the mean of μ1 and μ2.

4.13. EXAMINATION OF DIRECT EFFECTS – REGRESSION ANALYSIS

In order to examine the direct effects of:

(a) Perceived usefulness, attitude and facilitating conditions on intention for Augmented Reality dataset.

(b) Perceived ease of use, perceived usefulness and perceived enjoyment on attitude

(c) Perceived relative advantage, perceived enjoyment and perceived ease of use in perceived usefulness, and

(d) facilitating conditions and mobile self-efficacy on perceived ease of use

hierarchical regression analyses will be conducted.

The following assumptions regarding the regression analysis were checked and found that are met regarding the variables of Augmented Reality and Virtual Reality that have been used (APPENDIX C).

- The variables of both groups were normally distributed.
- The relationship between the dependent and independent variables was linear.
- There was no homoscedasticity in the variables of the dataset.
- There was no multicollinearity in the predictors.

(Berry, 1993).

Regression Analysis for Augmented Reality

Table 96 shows the regression analysis for AR.

Table 96. Regression Analysis for AR

Dependent Variable	Adjusted R^2	Independent Variable	F	Beta	t	p-value
Intention	.385	Perceived usefulness	10.592	.242	1.616	.133
		Attitude		.362	2.258	.029

		Facilitating conditions		.170	1.255	.216
Attitude	.617	Perceived ease of use	25.673	.311	2.775	.008
		Perceived usefulness		.315	2.911	.006
		Perceived enjoyment		.365	3.311	.002
Perceived usefulness	.360	Perceived relative advantage	9.615	.408	2.860	.007
		perceived enjoyment		.105	.705	.484
		perceived ease of use		.250	1.777	.083
Perceived ease of use	.161	Facilitating conditions	19.419	.408	2.777	.008
		Mobile self-efficacy		.343	2.335	.024

The adjusted R^2 for the dependent variable "Intention" shows that 38.5% of the variance in Intention is explained by Perceived Usefulness, Attitude, and Facilitating Conditions. Since p-value for Attitude is < .05 (here it is .029), the direct effect of Intention on attitude is significant. Whereas the p-value for Perceived Usefulness and Facilitating Conditions is >.05 (here these are .133, .216), hence the direct effect of Intention on Perceived Usefulness and Facilitating Conditions is insignificant.

The adjusted R^2 for the dependent variable "Attitude" indicates that 61.7% of the variance in Attitude is explained by Perceived Ease of Use, Perceived Usefulness, and Perceived Enjoyment. Since the p-values for Perceived Ease of Use, Perceived Usefulness, and Perceived Enjoyment are <.05 (.008, .006, and .002), hence the direct effect of Attitude on Perceived Ease of Use, Perceived Usefulness, and Perceived Enjoyment is significant.

The adjusted R^2 for the dependent variable "Perceived Usefulness" shows that 36% of the variance in Perceived Usefulness is explained by Perceived Relative Advantage, Perceived Enjoyment, and Perceived Ease of Use. Since the p-value for Perceived Relative Advantage is < .05 (here it is .007), hence the direct effect of Perceived Usefulness on Perceived Relative Advantage is significant. Whereas the p-values for Perceived Enjoyment and Perceived Ease of Use are both >.05 (.484 and .083), hence the direct effect of Perceived Usefulness on Perceived Enjoyment and Perceived Ease of Use is insignificant.

The adjusted R^2 for the dependent variable "Perceived Ease of Use" indicatesthat 16.1% of the variance in Perceived Ease of Use is explained by Facilitating Conditions and Mobile Self-Efficacy. Since the p-values for Facilitating Conditions and Mobile Self-Efficacy are< .05 (.008 and .024), hence the direct effect of Perceived Ease of Use on Facilitating Conditions and Mobile Self-Efficacy is significant.

Regression Analysis for Virtual Reality

Table 97 shows the regression analysis for VR.

Table 97. Regression analysis for VR

Dependent Variable	**Adjusted R^2**	**Independent Variable**	**F**	**Beta**	**t**	**p-value**
Intention	.488	Perceived usefulness	15.600	.406	3.269	.002
		Attitude		.344	2.744	.009
		Facilitating conditions		.212	1.977	.054
Attitude	.550	Perceived ease of use	19.768	.085	.766	.448
		Perceived usefulness		.283	2.493	.017
		Perceived enjoyment		.570	5.272	.000
Perceived usefulness	.429	Perceived relative advantage	12.515	.610	4.274	.000
		perceived enjoyment		-.022	-.161	.873
		perceived ease of use		.157	1.255	.216
Perceived ease of use	.490	Facilitating conditions	23.087	.179	1.656	.105
		Mobile self-efficacy		.651	6.008	.000

The adjusted R^2 for the dependent variable "Intention" shows that 48.8% of the variance in Intention is explained by Perceived Usefulness, Attitude, and Facilitating Conditions. Since the p-values for Perceived Usefulness and Attitude are <.05 (here it is .002 and .009), hence the direct effect of Intention on Perceived Usefulness and Attitude is significant. Whereas the p-value for Facilitating Conditions is > .05 (here it is .054), hence the direct effect of Intention on Facilitating Conditions is insignificant.

The adjusted R^2 for the dependent variable "Attitude" indicates that 55% of the variance in Attitude is explained by Perceived Ease of Use, Perceived Usefulness, and Perceived Enjoyment. Since the p-values for Perceived Usefulness and Perceived Enjoyment are <.05 (here these are .017, .000), hence the direct effect of Attitude on Perceived Usefulness and Perceived Enjoyment is significant. Whereas the p-value for Perceived Ease of Use is > .05 (here it is .448), hence the direct effect of Attitude on Perceived Ease of Use is insignificant.

The adjusted R^2 for the dependent variable "Perceived Usefulness" shows that 42.9% of the variance in Perceived Usefulness is explained by Perceived Relative Advantage, Perceived Enjoyment, and Perceived Ease of Use. Since the p-value for Perceived Relative Advantage is < .05 (here it is .000), hence the direct effect of Perceived Usefulness on Perceived Relative Advantage is significant. Whereas the p-values for Perceived Enjoyment and Perceived Ease of Use are >.05 (here these are .873 and .216), hence the direct effect of Perceived Usefulness on Perceived Enjoyment and Perceived Ease of Use is insignificant.

The adjusted R^2 for the dependent variable "Perceived Ease of Use" indicates that 49% of the variance in Perceived Ease of Use is explained by Facilitating Conditions and Mobile Self-Efficacy. Since the p-value for Mobile Self-Efficacy is < .05 (here these are .000), hence the direct effect of Perceived Ease of Use on Mobile Self-Efficacy is significant. Whereas the p-value for Facilitating Conditions is > .05 (here it is .105), hence the direct effect of Perceived Ease of Use on Facilitating Conditions is insignificant.

CHAPTER V: DISCUSSION AND CONCLUSIONS

In chapter V a discussion of the results is presented followed by conclusions and suggestions for future work. The discussion is presented according to the research questions of the study mentioned in chapter III (Methodology).

5.1. RESEARCH QUESTION 1

What is the user's technology acceptance of AR in terms of:

a. *Intention to use AR applications?*
b. *Attitude towards AR applications?*
c. *Perceived ease of use regarding AR applications*
d. *Perceived usefulness regarding AR applications?*
e. *Perceived relative advantage regarding AR applications?*
f. *Facilitating conditions regarding AR applications?*
g. *Perceived enjoyment regarding AR applications?*
h. *Mobile Self Efficacy regarding AR applications?*

The participants demonstrated a high intention to use AR applications in their teaching. More specifically, all their answers to the questions related to intend to use, plan to use and predict that they will use AR applications in their teaching had high values compared to the mid-range scores.

Regarding the Attitude towards the AR applications the participants had very positive responses. The positive level of their responses in the Attitude towards AR application was higher than the Intention to use AR applications. This could be explained, as the AR experiment was a pleasant and innovative experience and it created a high positive Attitude towards AR applications, whereas the Intention includes the factor of teaching. This means that they might consider also other factors, such as the real potential of using the AR applications in their teaching under specific circumstances, which could cause the small difference in the level of their positive responses.

Regarding the Perceived ease of use the participants had high scores but less than Intention and Attitude. This could be described as expected, as their experience with AR technologies were moderate as showed from the demographic data. Specifically, regarding the AR Head Mount Display device their experience was none in most of the cases and just minimum for a few. The lower rates of Perceived ease of use could be due to their first experience with a new technology that they were not familiar to.

Regarding perceived usefulness the participants' rates were in the highest levels. They reported that using AR applications could enhance teaching, it will be useful for teaching and could increase their teaching productivity. Similar to the Attitude, Perceived usefulness refers to a theoretical base about what they think of enhancing their teaching. It does not refer the actual use in their teaching. This could explain the very high levels they rated the Perceived usefulness as the prevailing conditions were not a deterrent factor to make them cautious.

Perceived relative advantage was referred to the comparison of AR applications with other technologies, participants' rates were high. Specifically, the question regarding the new learning opportunities offered by AR application compared to the existing technologies had the highest rate. Most of the participants were experiencing an AR activity with HMD device for their first time. This could make them think for the first time the new opportunities that such a technology could offer in their teaching. It is reasonable to need time and experience to think of how to use a new technology in the teaching process and what kind of opportunities you could utilize.

Regarding the Facilitating conditions which referred to the necessary resources, the knowledge and time needed to use AR applications in their teaching the participants' rates were above average (slightly high). It is important to mention that their rates in this variable were the lowest comparing to all other variables. This could be explained as the needed resources regarding AR applications and specifically HMD based are limited in schools.

Regarding Perceived enjoyment the participants' rates where the highest comparing with all the other variables. This means that they had fun during the experience and found the activity enjoyable. The AR experience where they were able to see virtual objects in the physical environment seemed to be an original, innovative, and exciting experience which made them feel good and give them pleasure during the activity.

Regarding the Mobile Self-Efficacy the participants' rates were slightly high. The highest rates were in the question about the completion of a job or task using a mobile device whereas the lowest rates were regarding the use of mobile technology for AR applications. As mentioned before, this could indicate that the participants were cautious about the use of technology or applications that have never used before.

Similar positive findings as those mentioned above have also been found in previous studies which examined users' intention to use AR applications (Arifin, Sastria, & Barlian, 2018; Bekarooa et al. 2018; Georgiou & Kyza, 2017; Jang et al. 2020, Jung et al. 2020).

Regarding the relationships between the eight variables the results showed that the Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy are related with the intention of the participants. More specifically, the higher the participants' rate on Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy, the stronger their Intention was to use AR applications to their teaching. Similar findings regarding the relationships of the factors mentioned above, are in line with recent study in AR applications using the same acceptance model, MARAM (Koutromanos & Mikropoulos, 2021).

Regarding the regression analysis, the direct factor that was found to affect the intention was the attitude of the students. This means that by enhancing the positive attitude of the users it is likely to increase their intention to use AR in their teaching. This could be fulfilled if a positive attitude would be cultivated during undergraduate studies of future teachers as well as a training for active teachers. This could be provided by describing the advantages of AR in learning, the ways that AR could be used for learning purposes, examples of AR applications for learning supported by adequate empirical work, showing the true gains of AR. This finding is in line with previous research about technology acceptance (Koutromanos & Mikropoulos, 2021).

Regarding the Attitude, the direct effects that were found to affect it, were mostly Perceived enjoyment and afterwards Perceived usefulness and Perceived ease of use. This means that in order to enhance users' Attitude the Perceived enjoyment must first of all increase. A suggested way to increase the Perceived enjoyment would be to design attractive AR applications. Similarly, perceived usefulness and perceived ease of use could be also increased in case users would have the opportunity to know about the advantages of AR in learning and interact more with AR applications.

Regarding the Perceived usefulness, the direct effect that was found to affect it, was the Perceived relative advantage. A suggestion to increase the Perceived usefulness would be to create trainings about the AR advantages compared with other technologies.

Finally, regarding the Perceived ease of use, the direct effect that was found to affect it, was the Facilitating conditions. By increasing the knowledge and skills of future teachers and providing the necessary resources, the Perceived ease of use is likely to increase. In addition, the Perceived ease of use is also likely to increase if teachers will have the time needed to use AR applications in their teaching (Baturay, Gökçearslan, & Ke, 2017; Koutromanos & Mikropoulos, 2021).

Following the suggestions mentioned above, the educational policy should take into consideration the direct factors found to affect Intention, Attitude, Perceived usefulness and Perceived ease of use. In this context, the curricula should provide training about the advantages of AR in learning, the advantages of AR in learning compared with other technologies, the ways that AR could be used for learning purposes, examples of AR applications for learning and how to use AR technologies. In addition, schools should be equipped with the necessary resources needed to use AR, such as mobiles, tablets, HMD devices, etc. and adjust curricula in a way that teachers will have the time needed to use AR applications in their teaching.

5.2. RESEARCH QUESTION 2

What is the user's technology acceptance of VR in terms of:

- *b. Intention to use VR applications?*
- *c. Attitude towards VR applications?*
- *d. Perceived ease of use regarding VR applications*
- *e. Perceived usefulness regarding VR applications?*
- *f. Perceived relative advantage regarding VR applications?*
- *g. Facilitating conditions regarding VR applications?*
- *h. Perceived enjoyment regarding VR applications?*
- *i. Mobile Self Efficacy regarding VR applications?*

The participants' responses regarding the VR application had the same range as in the AR application. The participants demonstrated the highest levels in Perceived Enjoyment and Attitude, they had lower levels but still very high in Perceived usefulness, Perceived Relative advantage, and Intention and even lower but still high in Mobile Self Efficacy, Perceived ease of use and last in Facilitating conditions. VR application was really enjoyable for the students as they were immersed into a totally different environment and could move and feel as they were somewhere else. In addition, the very high levels in Attitude show that they had a very pleasant experience. Regarding the Facilitating conditions the students had the lowest rates, as in AR. This could be similarly explained, as the needed resources regarding VR applications and specifically HMD based are limited in schools. In addition, undergraduate students future teachers are not often offered trainings regarding such technologies for learning (VR/AR applications) (Jang et al. 2020).

Regarding the relationships between the eight variables the results were similar to the AR and showed that the Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy are related with the intention of the participants. More specifically, the higher the participants' rate on Attitude, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment and Mobile Self-Efficacy the stronger their Intention was to use AR applications to their teaching.

5.3. RESEARCH QUESTION 3

What is the relationship between technology acceptance of AR and VR?

Regarding the comparison of AR and VR, Intention, Attitude, Facilitating conditions and Perceived enjoyment were the same in AR and VR. On the other hand, Perceived ease of use, Perceived usefulness, Perceived Relative Advantage and Mobile Self-Efficacy were higher in VR. This means, that we could conclude that the technology acceptance of VR was higher in comparison with AR.

5.4. RESEARCH QUESTION 4

What is the user's sense of presence in AR?

The participants reported that they were in the same place as the waves and that they were feeling that they experienced real events in the real world. The participants' responses were in a high level regarding the feeling that they could reach and touch the waves and that they were among the waves. This is expected as the environment of the AR application was the physical environment. This could also be because the digital waves were presented in physical alignment with the real world and that the interaction with the physical objects were the reason to experience the activity as it was entirely real.

The participants demonstrated an average level regarding the feeling that the waves were headed toward them and a low level in trying to touch them. The reason for this could be that the AR Head Mounted Display Device has a limited field of view, namely the digital objects cannot be seen inscribed along.

These findings are in line with previous research in the examination of the sense of presence in AR (Regenbrecht & Schubert, 2021; Vrellis et al. 2020).

5.5. RESEARCH QUESTION 5

What is the user's sense of presence in VR?

The participants demonstrated very high levels of sense of presence in VR. They showed that they felt immersed and that they were experiencing the activity as if it was real. Similar positive findings were found in a previous study (Servotte et al. 2020).

5.6. RESEARCH QUESTION 6

What is the relationship between user's sense of presence in AR and VR?

As far as the comparison of the spatial presence between the AR and VR application is concerned, regarding the questions "How much did it seem as if the virtual waves you were seeing were in the same place as you", "How much did it seem as if you could reach out and touch the virtual waves you were seeing", "To what extent did you experience a sense of being among the virtual waves you have seen", "How often did you want to or try to touch a virtual wave that you saw" and "How would you describe your experience: as if you were watching through a monitor or watching events in the real world" the sense of spatial presence was the same in AR and VR. According to the participants, there was a higher sense of spatial presence in the VR application regarding the frequency they wanted to move to get out of the waves' way when the virtual waves seemed to be headed toward them and the frequency, they wanted to try to touch a virtual wave that they saw.

This means, that we could conclude that the sense of presence was higher in VR in comparison with AR. The reason for this could be that in the VR application the participants were totally immersed and that the virtual environment was in the entire field of their view, whereas in the AR application the digital waves were presented in a limited field of view due to the head worn glasses.

5.7. RESEARCH QUESTIONS 7,8 AND 9

What is the user's simulator sickness in AR?

What is the user's simulator sickness in VR?

What is the relationship between user's simulator sickness in AR and VR?

In both the AR and VR environments, the participants experienced very low levels of simulator sickness while using the relevant applications. This is in line with the study of Iatraki et al. (2021).

Regarding the relationship between user's simulator sickness in AR and VR, General Discomfort, Fatigue, Headache, Nausea and Stomach Awareness were the same in AR and VR. On the other hand, Eyestrain, Difficulty Focusing, Sweating, Difficulty Concentrating, Fullness of the Head, Blurred Vision and Dizziness with Eyes Open were higher in VR, whereas Salivation Increasing was higher in AR. This means, that we could conclude that Immersion was better in AR in comparison with VR.

In conclusion

In conclusion, this study argues that the technological affordances have positive effects on the acceptance of AR for learning purposes. More specifically, it examined the effects of the technological affordances of AR through a technology acceptance model, a spatial presence and simulator sickness questionnaire. An AR application was developed in line with the AR affordances mentioned above regarding electromagnetic waves emitting from wireless devices of the real world. The technological affordances of the AR application were evaluated in terms of Intention to use AR applications, Attitude towards AR applications, Perceived ease of use, Perceived usefulness, Perceived relative advantage, Facilitating conditions, Perceived enjoyment, Mobile Self Efficacy regarding AR applications, users sense of spatial presence during the AR activity and simulator sickness. In addition, the technological affordances of the AR application were also examined through the comparison with a similar VR application which was developed. Given that the differences between AR and VR technological affordances are those mentioned in section 2.4.7, the comparison of the two technologies allow us to evaluate the effects of those technological affordances. The results showed that the technological affordances of AR effect the acceptance of AR technology as all the examined variables have been rated very high. In addition, 48.8% of the variance in Intention to use AR applications in teaching was explained by specific variables (Attitude, Perceived usefulness, Facilitating conditions). In addition, the sense of spatial presence was also very high in AR. Regarding the comparison of AR with VR, technology acceptance and the sense of spatial presence seemed to be higher in VR whereas the immersion seemed to be better in AR.

This study contributes to the existing literature regarding the acceptance of the technology of AR for learning purposes. More specifically, it contributes by providing for the first-time data from an empirical study that has used head-worn glasses for the AR application and has been compared with an HMD VR technology for the examination of the technological affordances.

5.8. LIMITATIONS

Referring to the limitations of the study these include the number of the participants. A total of 47 students is considered a relatively small sample quantity. In addition, due to restricted circumstances this study used the same sample for the AR and VR activity. Two different samples could be used each one for AR and VR respectively.

5.9. FUTURE WORK

Future research should further examine these initial findings by using a larger sample to test both technology acceptance and MARAM itself. In addition, in-service teachers could be used as a sample to study real situations in the classroom. Another factor that should be examined is the learning activities in order to study the acceptance and the learning outcomes.

Regarding the MARAM questionnaire that was used to examine the technology acceptance of AR and VR technology, as mentioned in the second chapter, it is related indirectly with the technological affordances. The MARAM questionnaire could be modified in order to integrate factors which refer more specifically to AR technological affordances. Future research should examine which questions and under what section should be added in this context. In addition, future studies could also examine the factor of modifying the MARAM questionnaire in order to refer in specific to AR head worn glasses technologies.

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APPENDIX A: QUESTIONNAIRE

Augmented Reality Applications

* Απαιτείται

SECTION A

1. Προσωπικές πληροφορίες

1. 1.1. Gender *

Να επισημαίνεται μόνο μία έλλειψη.

- Male
- Female

2. 1.2 Age *

3. 1.3 Experience *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Not at all	Slightly	Moderately	Very	Extremely
How experienced do you consider yourself in using a PC?					
How experienced do you consider yourself in using video games?					
How experienced do you consider yourself in Virtual Reality technologies?					
How experienced do you consider yourself in Augmented Reality technologies?					

SECTION B

4. Section B1: Intention *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I intend to use AR applications in my future teaching.	⬭	⬭	⬭	⬭	⬭
Using AR applications is a good idea.	⬭	⬭	⬭	⬭	⬭
I like using AR applications.	⬭	⬭	⬭	⬭	⬭

5. Section B2: Attitude *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Using AR applications is a good idea.	⬭	⬭	⬭	⬭	⬭
I like using AR applications.	⬭	⬭	⬭	⬭	⬭
It is desirable to use AR applications.	⬭	⬭	⬭	⬭	⬭

6. Section B3: Perceived ease of use *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My interaction with AR applications is clear and understandable.					
It is easy for me to become skillful at using AR applications.					
I find AR applications easy to use.					

7. Section B4: Perceived usefulness *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Using AR applications enhances my teaching effectiveness.					
AR applications are useful for my teaching.					
Using AR applications increases my teaching productivity.					

8. Section B5: Perceived relative advantage *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Stongly Agree
AR applications would be more advantageous in my teaching than other technologies.					
AR applications would make my teaching more effective than other technologies.					
AR applications are relatively efficient in my teaching compared to existing technologies.					
The use of AR applications offers new learning opportunities compared to existing technologies.					
Overall, AR applications are better than existing technologies.					

9. Section B6: Facilitating conditions *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have the resources (e.g., Internet connection, tablets) necessary to use AR applications in my teaching.					
I have the knowledge needed to use AR applications in my teaching.					
I have the time needed to use AR applications in my teaching.					

10. Section B7: Perceived enjoyment *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Using AR applications is truly fun.	⬭	⬭	⬭	⬭	⬭
I know using AR applications to be enjoyable.	⬭	⬭	⬭	⬭	⬭
The use of AR applications gives me pleasure.	⬭	⬭	⬭	⬭	⬭
The use of AR applications makes me feel good.	⬭	⬭	⬭	⬭	⬭

11. Section B8: Mobile Self-Efficacy *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I could complete a job or task using a mobile device.	⬭	⬭	⬭	⬭	⬭
I could complete a job or task using a mobile device if someone showed me how to do it.	⬭	⬭	⬭	⬭	⬭
I was fully able to use a mobile device before I began using AR applications.	⬭	⬭	⬭	⬭	⬭
I am confident that I can effectively use AR applications using mobile technology.	⬭	⬭	⬭	⬭	⬭
I believe I can use AR applications using mobile technology even if I have never used a similar technology before.	⬭	⬭	⬭	⬭	⬭

SECTION C

C1. Spacial Presense (TPI-SP)

12. How much did it seem as if the virtual waves you were seeing were in the same place as you? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Not at all	◯	◯	◯	◯	◯	◯	◯	Very much

13. How much did it seem as if you could reach out and touch the virtual waves you were seeing? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Not at all	◯	◯	◯	◯	◯	◯	◯	Very much

14. How often when the wirtual waves seemed to be headed toward you did you want to move to get out of its way? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Never	◯	◯	◯	◯	◯	◯	◯	Always

15. To what extent did you experience a sense of being among the virtual waves you have seen? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Not at all	◯	◯	◯	◯	◯	◯	◯	Very much

16. How often did you want to or try to touch a virtual wave that you saw? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Never	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Always

17. How would you describe your experience: as if you were watching through a monitor or watching events in the real world? *

Να επισημαίνεται μόνο μία έλλειψη.

	1	2	3	4	5	6	7	
Screen	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Real world

18. C2. Sickness (SSQ) *

Να επισημαίνεται μόνο μία έλλειψη ανά σειρά.

	None	Slight	Moderate	Severe
General Discomfort				
Fatigue				
Headache				
Eyestrain				
Difficulty Focusing				
Salivation Increasing				
Sweating				
Nausea				
Difficulty Concentrating				
Fullness of the Head				
Blurred Vision				
Dizziness with Eyes Open				
Dizziness with Eyes Closed				
Vertigo				
Stomach Awareness				
Burbing				

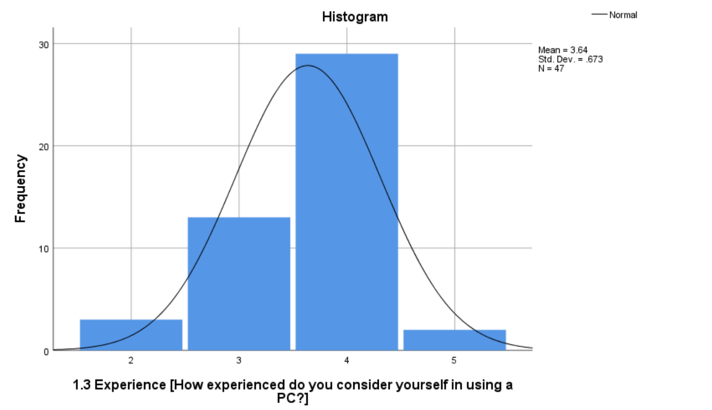
APPENDIX B: Normality Tests (Kolmogorov-Smirnov)

Variable 1

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
1.3 Experience [How experienced do you consider yourself in using a PC?]	.364	47	.000	.769	47	.000
a. Lilliefors Significance Correction						

PC

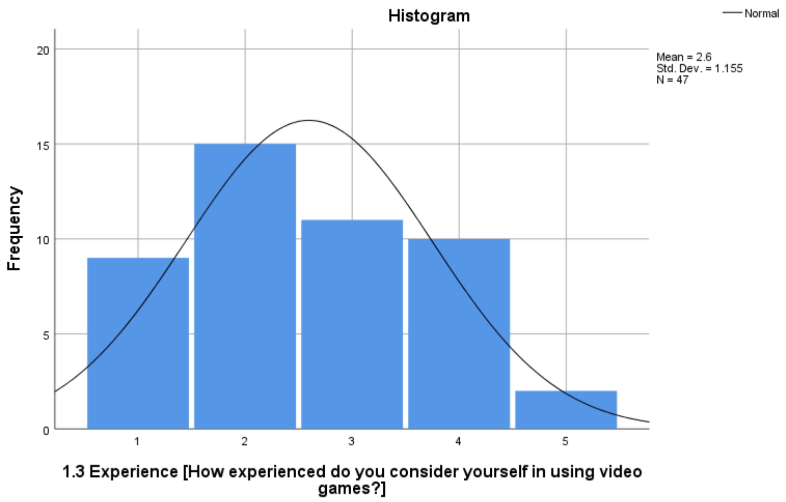


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the left distribution.

Variable 2

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
1.3 Experience [How experienced do you consider yourself in using video games?]	.208	47	.000	.902	47	.001
a. Lilliefors Significance Correction						



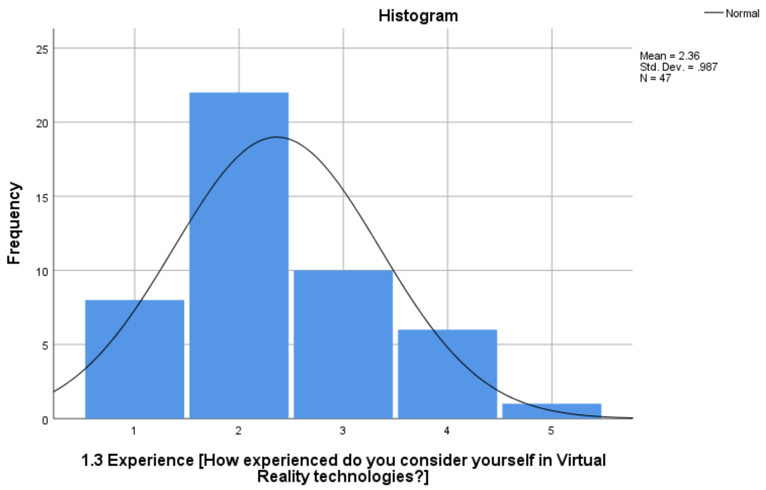
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the right distribution.

Variable 3

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
1.3 Experience [How experienced do you consider yourself in Virtual Reality technologies?]	.281	47	.000	.873	47	.000

a. Lilliefors Significance Correction

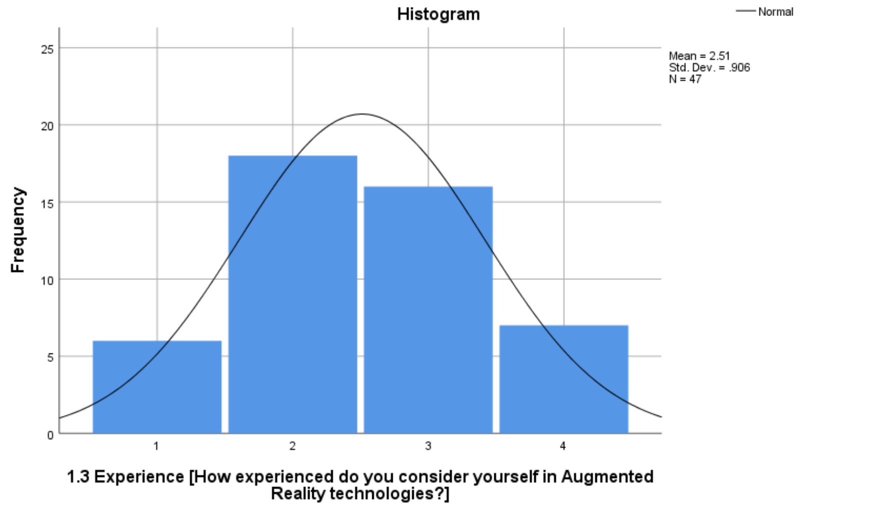


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the right distribution.

Variable 4

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
1.3 Experience [How experienced do you consider yourself in Augmented Reality technologies?]	.224	47	.000	.880	47	.000
a. Lilliefors Significance Correction						

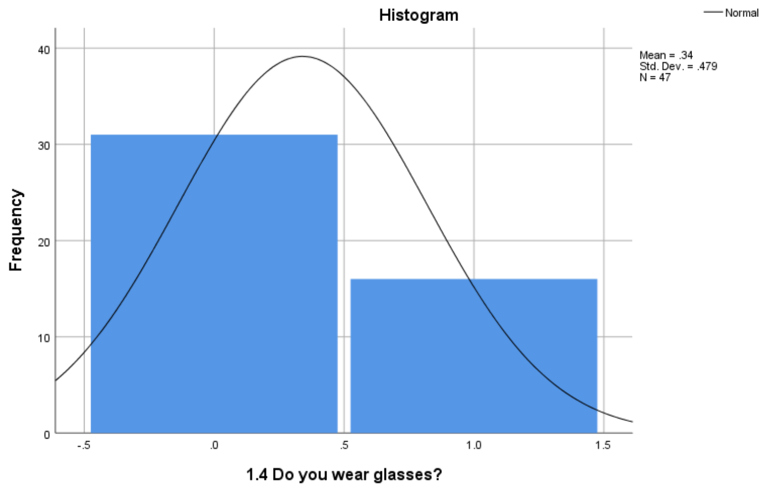
Table 7: Normality Result (Kolmogorov Smirnov) – User's experience in Augmented Reality



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 5

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
1.4 Do you wear glasses?	.421	47	.000	.599	47	.000
a. Lilliefors Significance Correction						

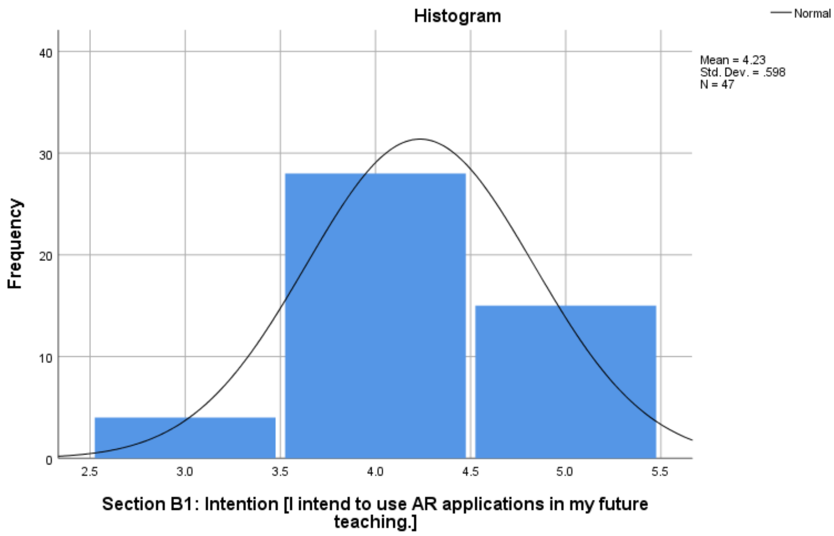


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 6

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B1: Intention [I intend to use AR applications in my future teaching.]	.333	47	.000	.755	47	.000
a. Lilliefors Significance Correction						

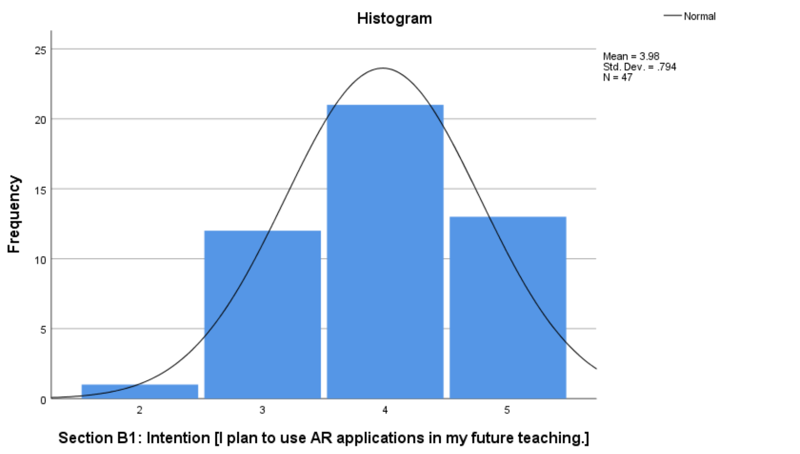


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed.

Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 7

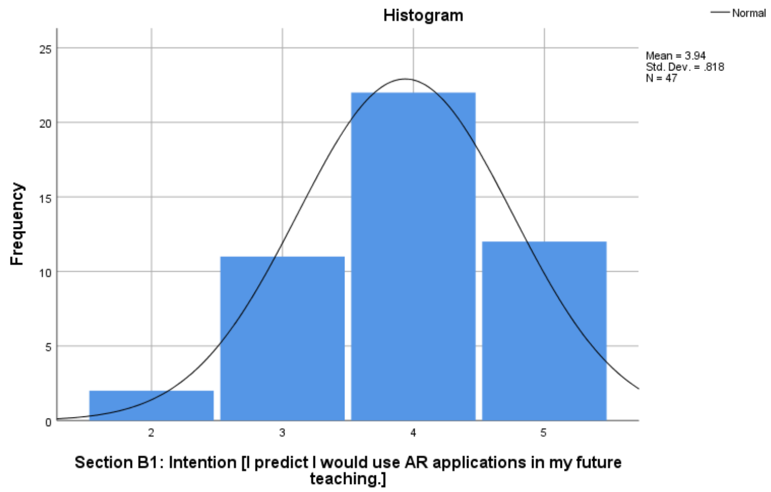
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B1: Intention [I plan to use AR applications in my future teaching.]	.234	47	.000	.845	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the left distribution.

Variable 8

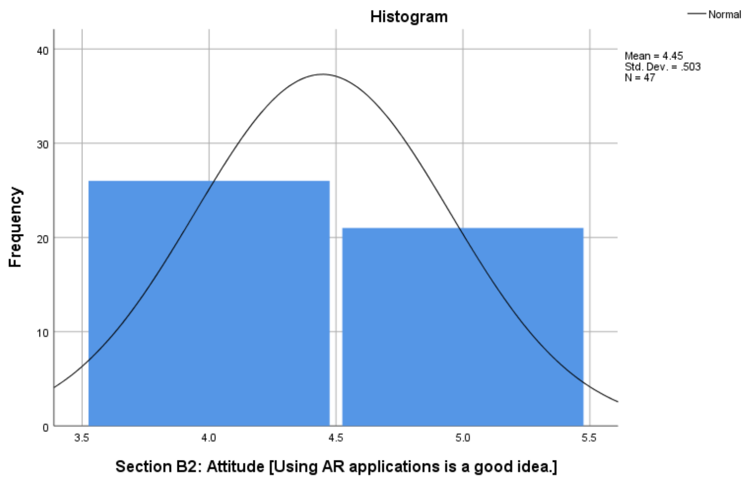
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B1: Intention [I predict I would use AR applications in my future teaching.]	.254	47	.000	.853	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the left distribution.

Variable 9

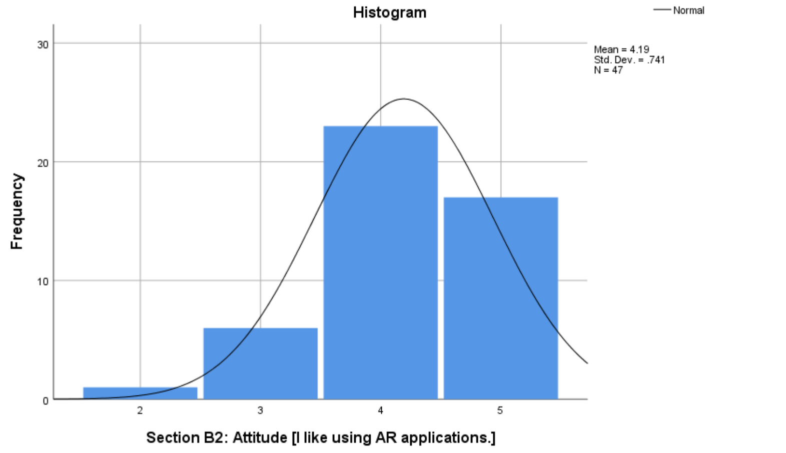
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B2: Attitude [Using AR applications is a good idea.]	.366	47	.000	.633	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 10

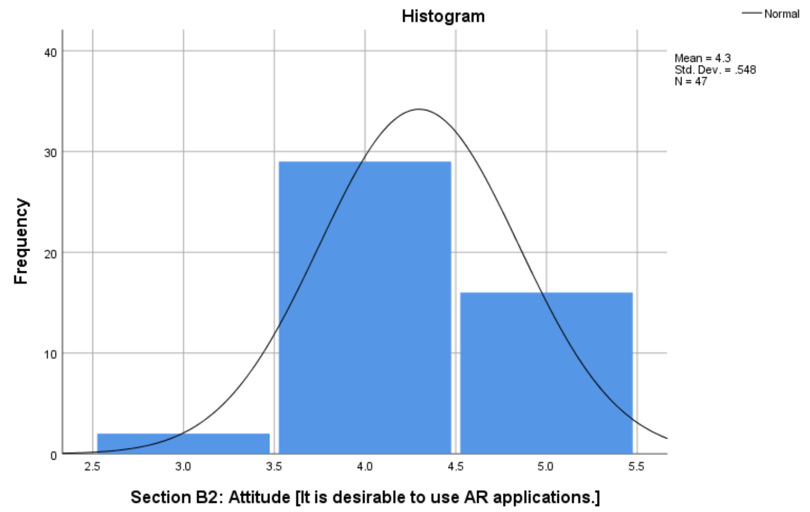
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B2: Attitude [I like using AR applications.]	.249	47	.000	.809	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather values have a skewed to the left distribution.

Variable 11

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B2: Attitude [It is desirable to use AR applications.]	.366	47	.000	.714	47	.000
a. Lilliefors Significance Correction						



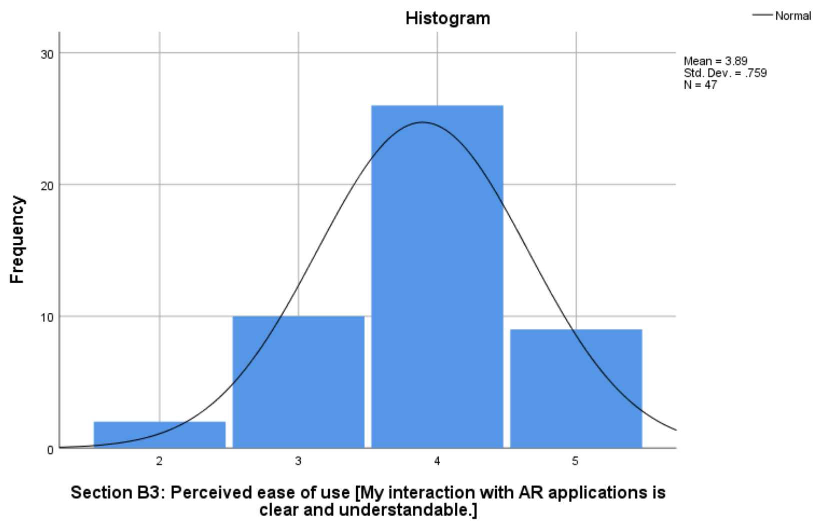
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 12

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B3: Perceived ease of use [My interaction with AR applications is clear and understandable.]	.300	47	.000	.836	47	.000

a. Lilliefors Significance Correction

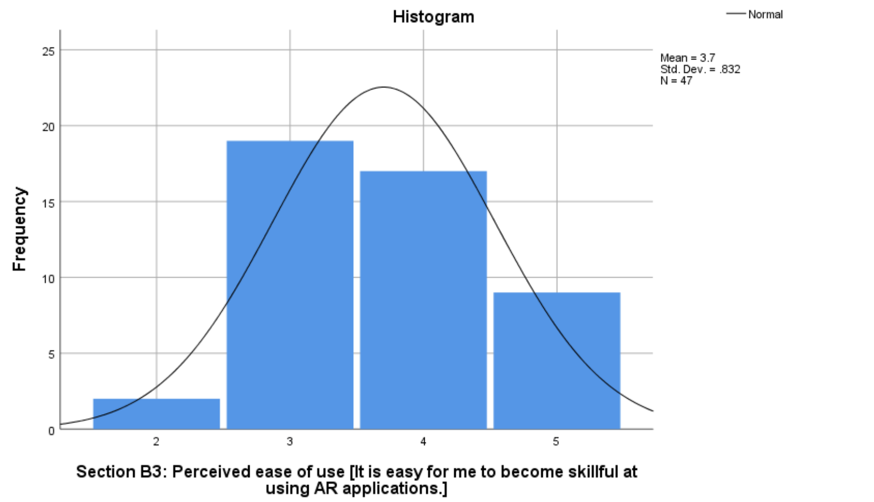


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed.

Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 13

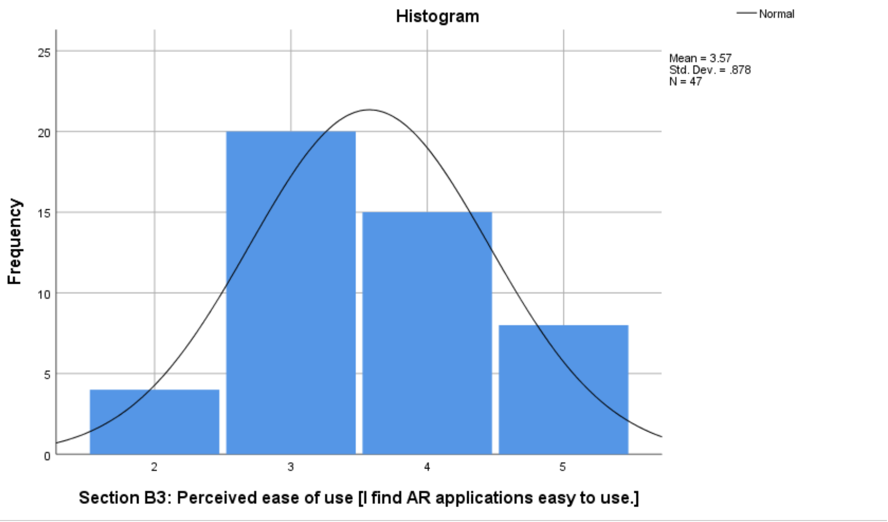
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B3: Perceived ease of use [It is easy for me to become skillful at using AR applications.]	.247	47	.000	.853	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 14

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B3: Perceived ease of use [I find AR applications easy to use.]	.254	47	.000	.866	47	.000
a. Lilliefors Significance Correction						



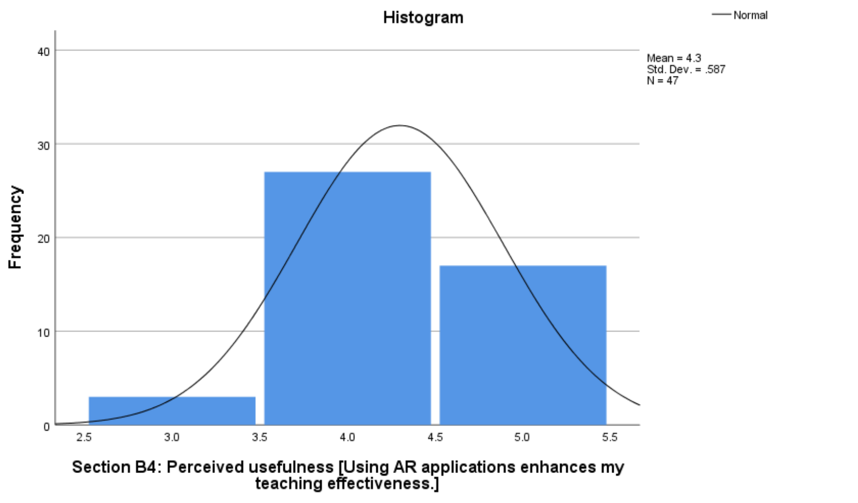
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 15

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B4: Perceived usefulness [Using AR applications enhances my teaching effectiveness.]	.332	47	.000	.744	47	.000

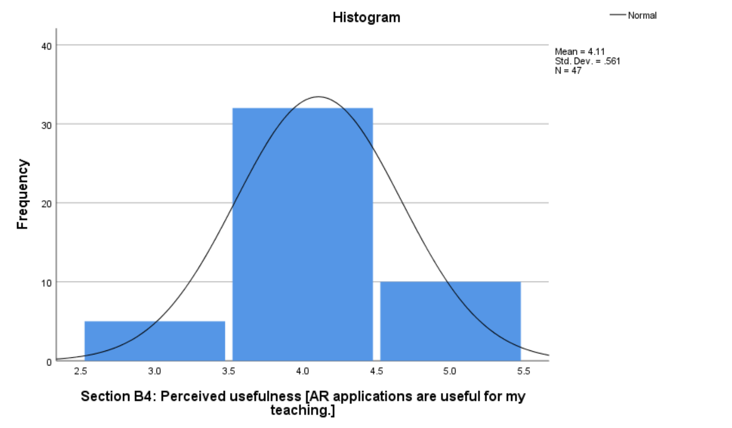
a. Lilliefors Significance Correction



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 16

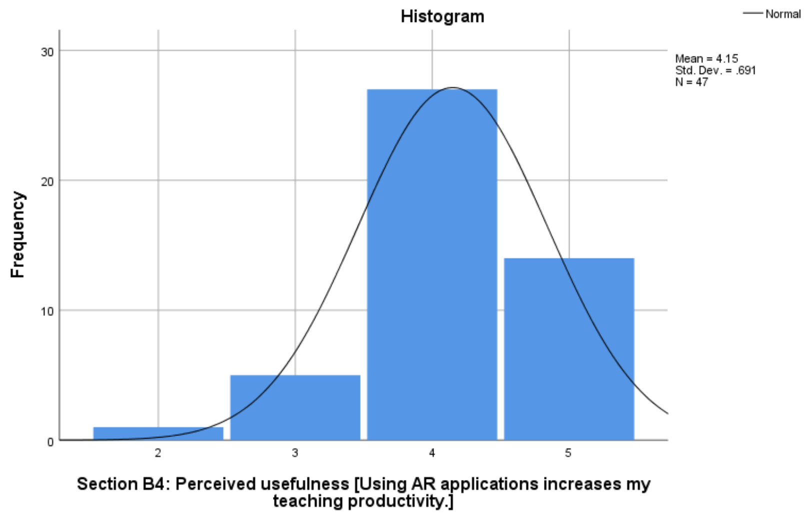
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B4: Perceived usefulness [AR applications are useful for my teaching.]	.362	47	.000	.732	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 17

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B4: Perceived usefulness [Using AR applications increases my teaching productivity.]	.287	47	.000	.792	47	.000
a. Lilliefors Significance Correction						



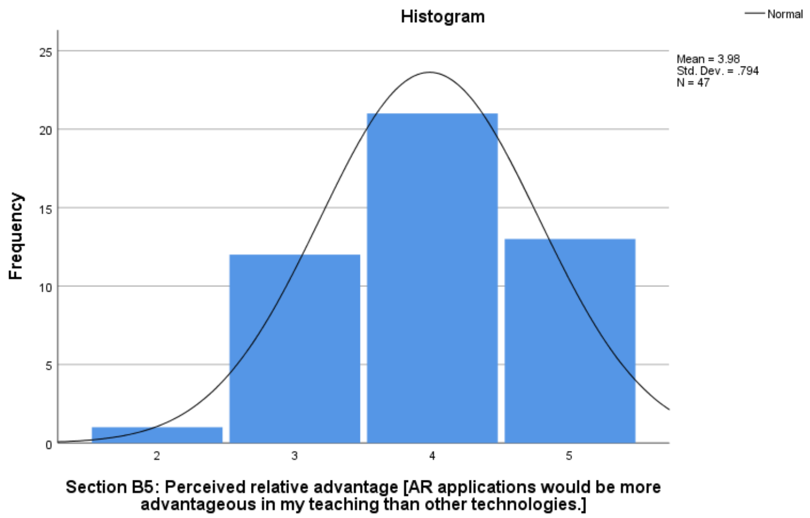
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 18

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B5: Perceived relative advantage [AR applications would be more advantageous in my teaching than other technologies.]	.234	47	.000	.845	47	.000

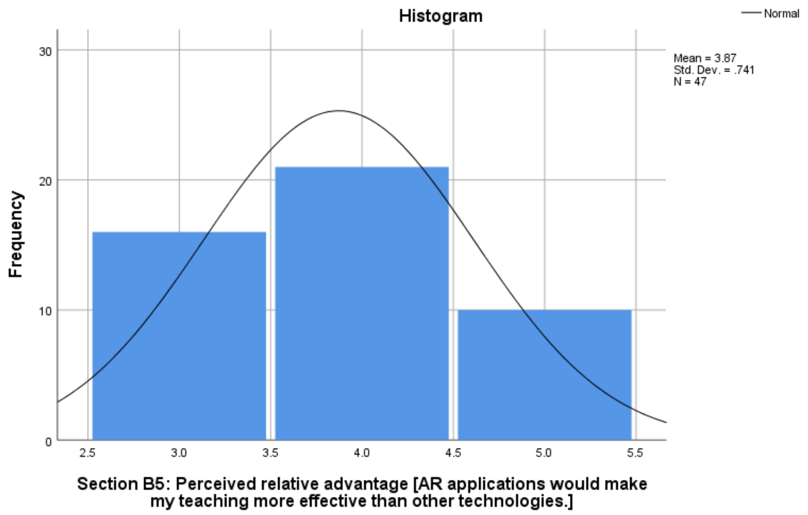
a. Lilliefors Significance Correction



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 19

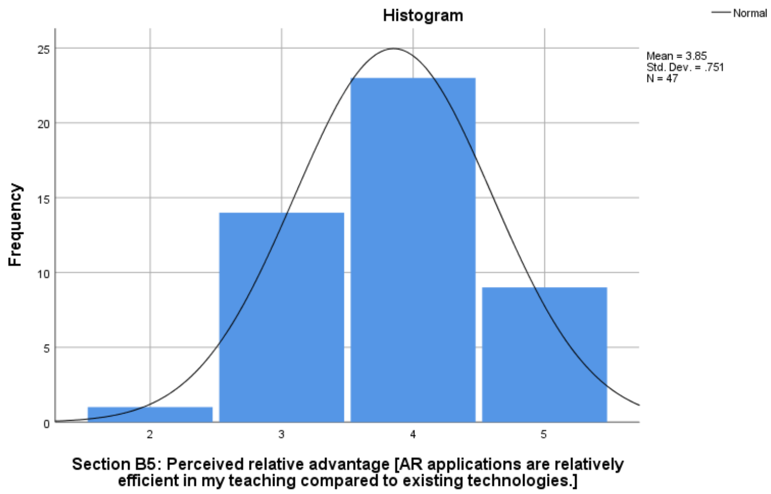
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B5: Perceived relative advantage [AR applications would make my teaching more effective than other technologies.]	.228	47	.000	.805	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 20

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B5: Perceived relative advantage [AR applications are relatively efficient in my teaching compared to existing technologies.]	.259	47	.000	.843	47	.000
a. Lilliefors Significance Correction						



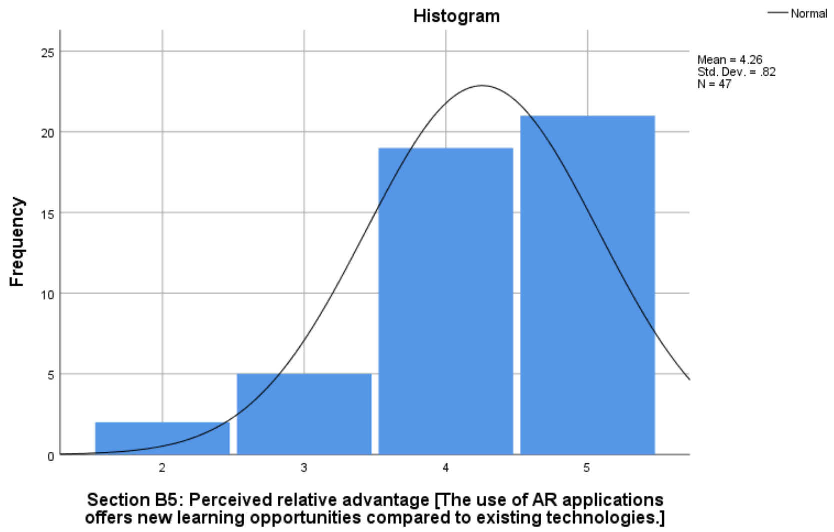
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 21

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B5: Perceived relative advantage [The use of AR applications offers new learning opportunities compared to existing technologies.]	.265	47	.000	.787	47	.000

a. Lilliefors Significance Correction



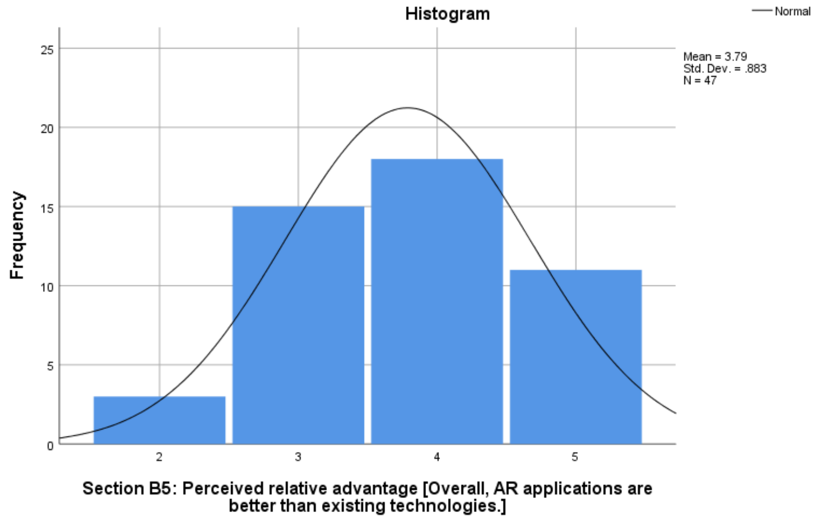
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 22

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B5: Perceived relative advantage [Overall, AR applications are better than existing technologies.]	.212	47	.000	.869	47	.000

a. Lilliefors Significance Correction



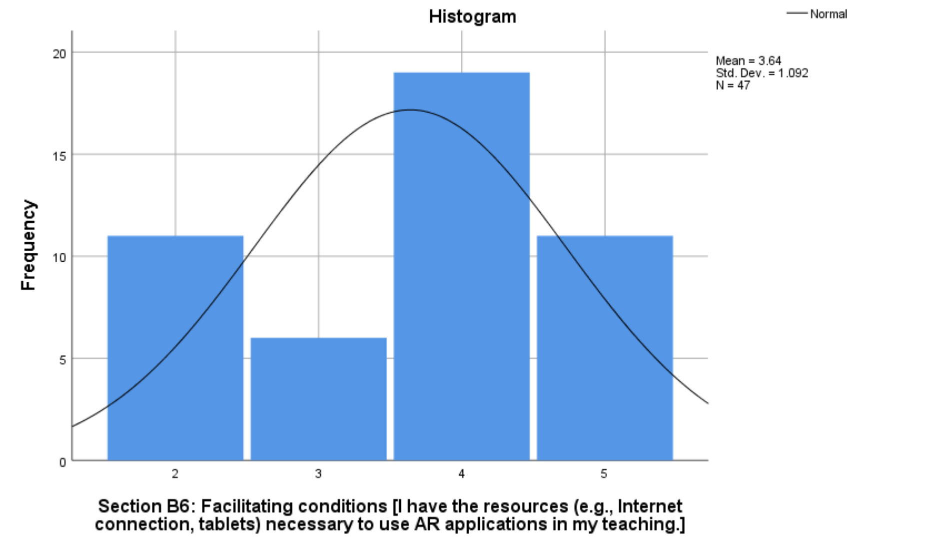
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 23

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B6: Facilitating conditions [I have the resources (e.g., Internet connection, tablets) necessary to use AR applications in my teaching.]	.268	47	.000	.837	47	.000

a. Lilliefors Significance Correction



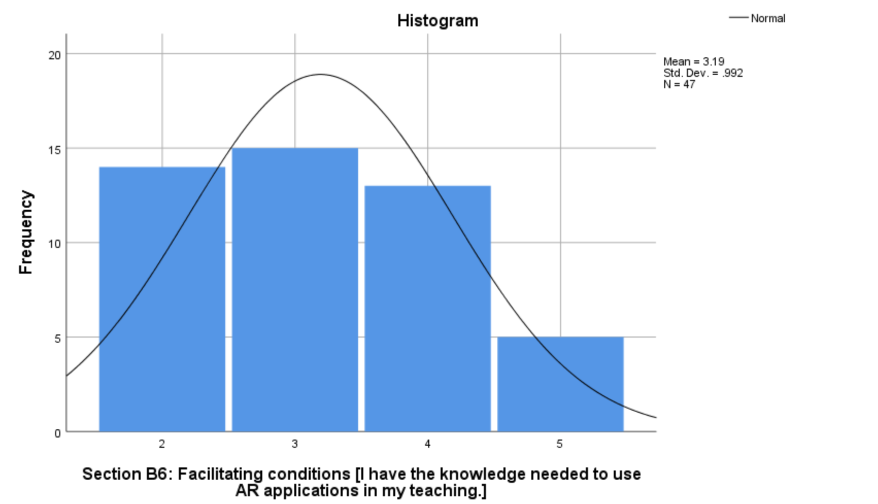
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 24

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B6: Facilitating conditions [I have the knowledge needed to use AR applications in my teaching.]	.194	47	.000	.864	47	.000

a. Lilliefors Significance Correction



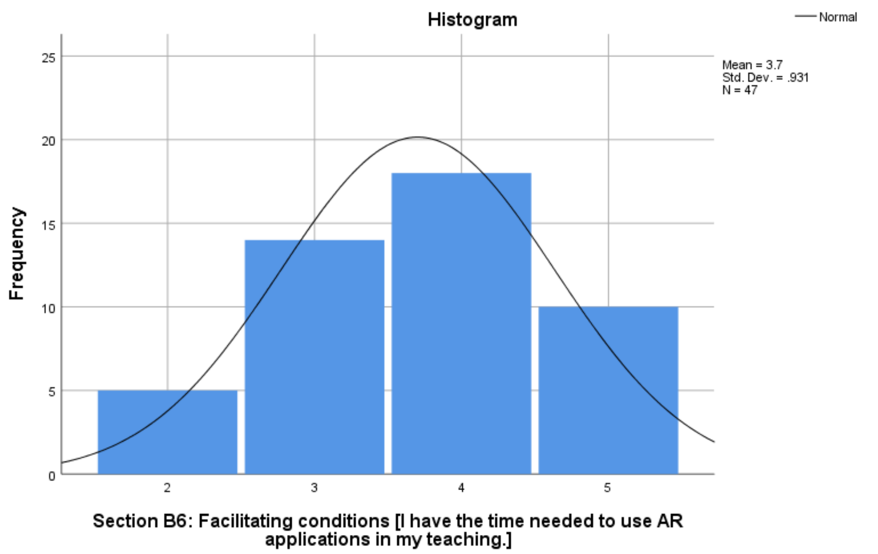
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

Variable 25

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B6: Facilitating conditions [I have the time needed to use AR applications in my teaching.]	.221	47	.000	.877	47	.000

a. Lilliefors Significance Correction



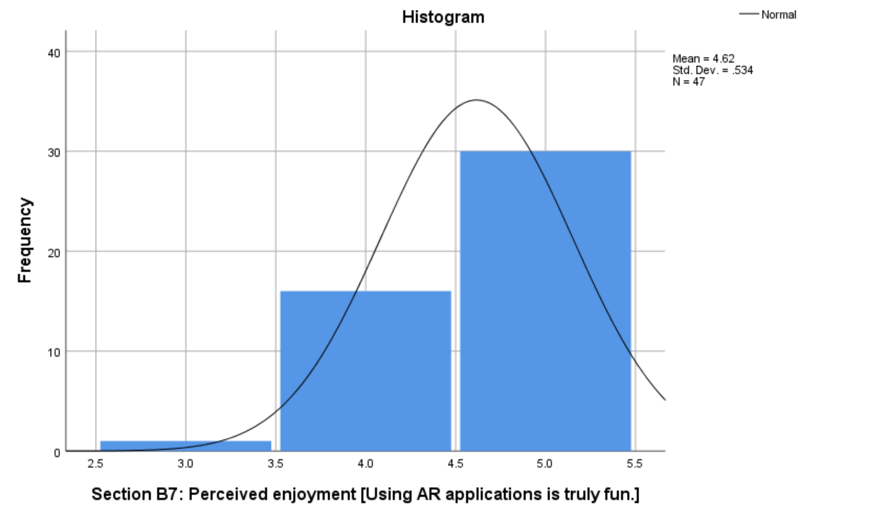
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 26

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B7: Perceived enjoyment [Using AR applications is truly fun.]	.402	47	.000	.654	47	.000

a. Lilliefors Significance Correction

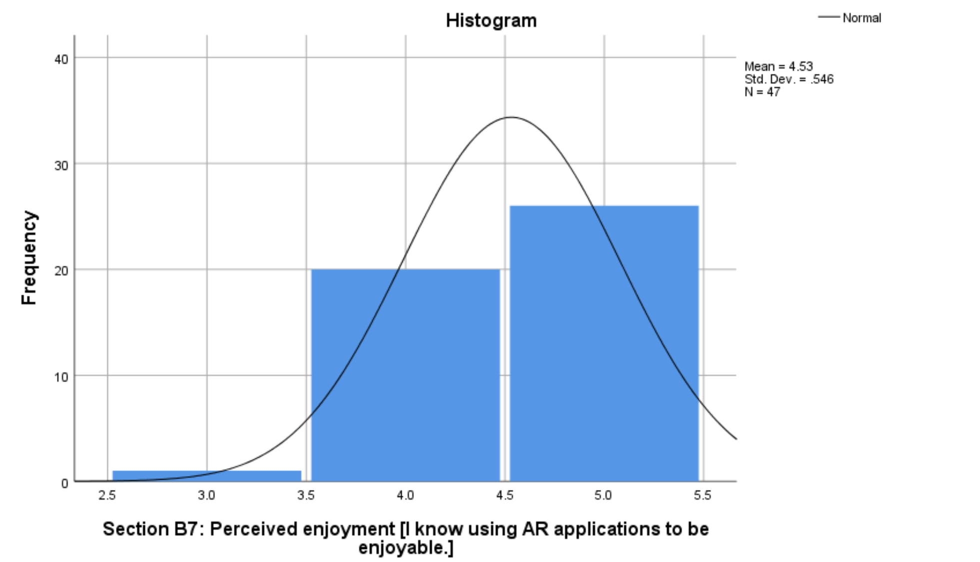


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather it is skewed to the left.

Variable 27

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B7: Perceived enjoyment [I know using AR applications to be enjoyable.]	.358	47	.000	.688	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed.

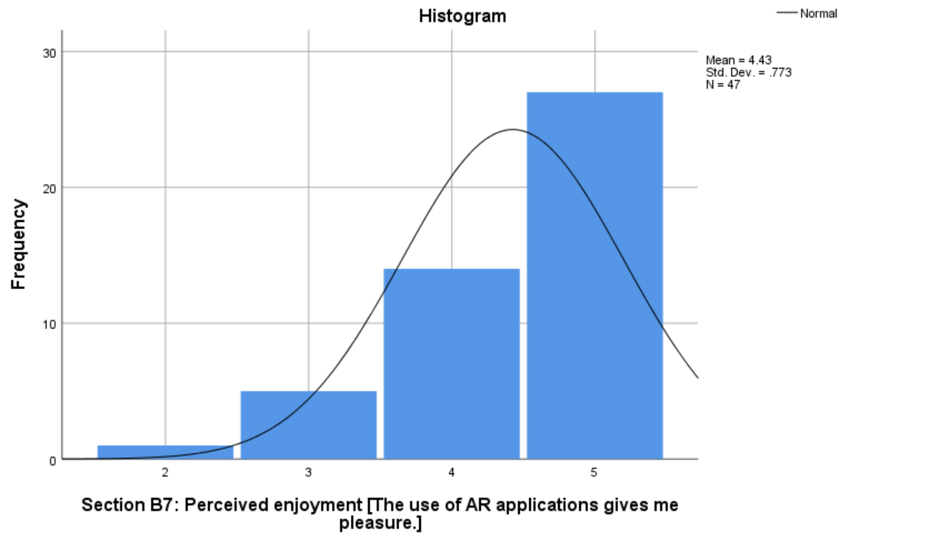
Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather it is skewed to the left.

Variable 28

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B7: Perceived enjoyment [The use of AR applications gives me pleasure.]	.346	47	.000	.730	47	.000

a. Lilliefors Significance Correction



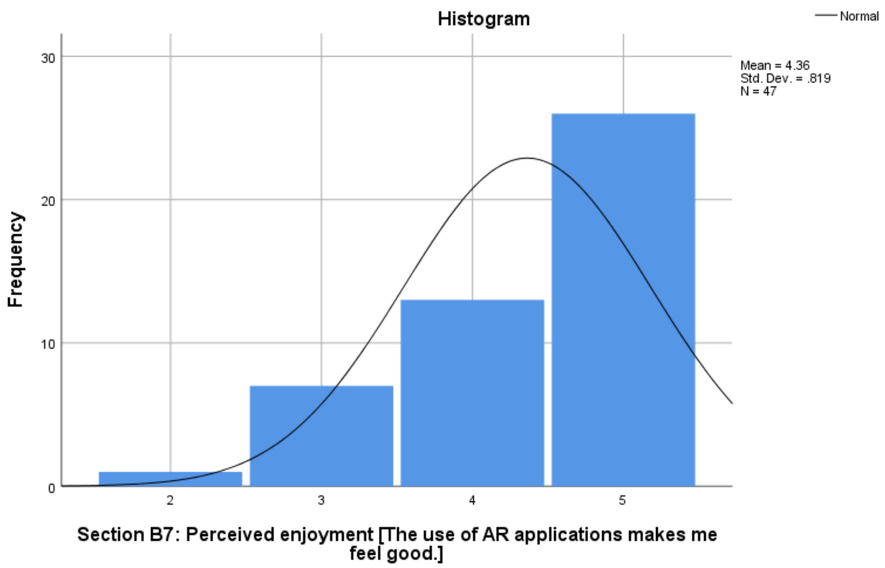
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather it is skewed to the left.

Variable 29

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B7: Perceived enjoyment [The use of AR applications makes me feel good.]	.335	47	.000	.749	47	.000

a. Lilliefors Significance Correction



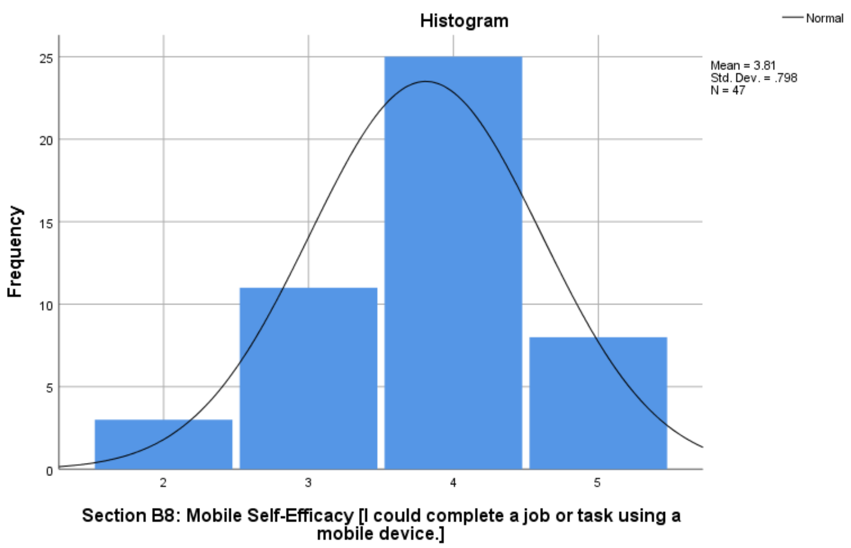
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather it is skewed to the left.

Variable 30

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B8: Mobile Self-Efficacy [I could complete a job or task using a mobile device.]	.297	47	.000	.846	47	.000

a. Lilliefors Significance Correction



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed.

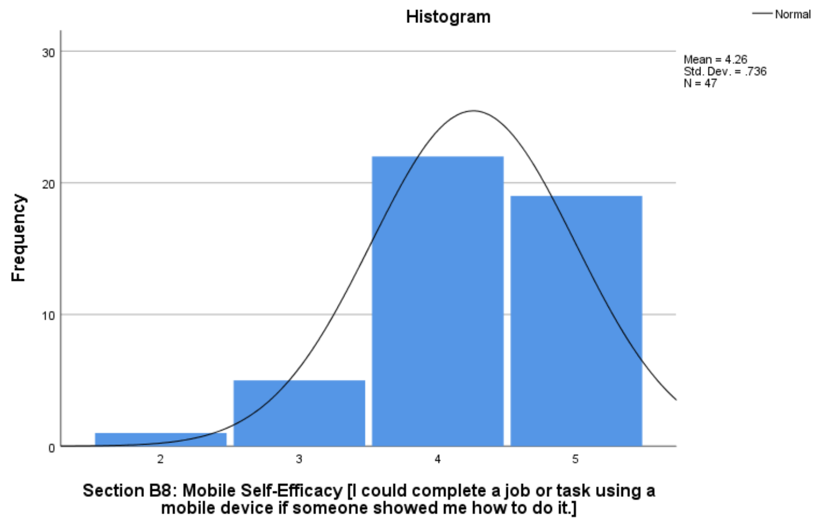
Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 31

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B8: Mobile Self-Efficacy [I could complete a job or task using a mobile device if someone showed me how to do it.]	.248	47	.000	.794	47	.000

a. Lilliefors Significance Correction



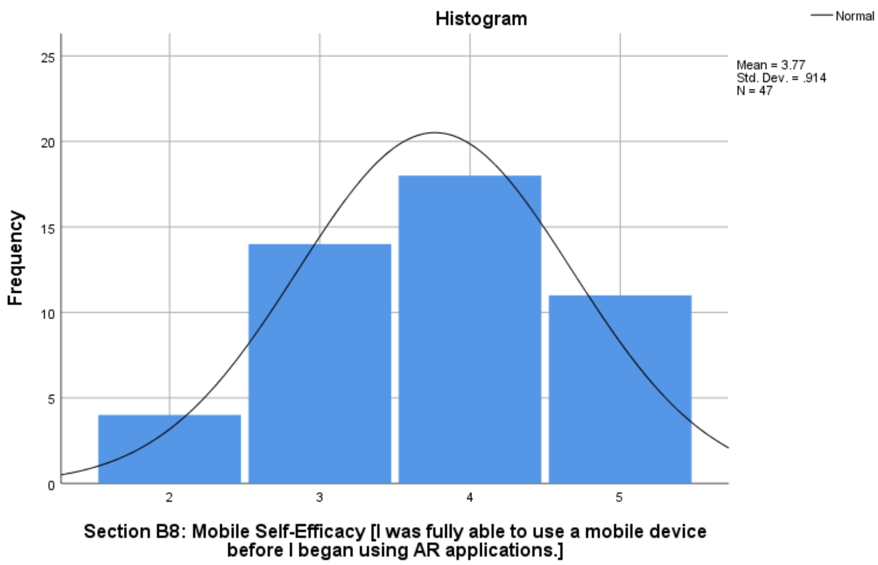
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 32

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B8: Mobile Self-Efficacy [I was fully able to use a mobile device before I began using AR applications.]	.218	47	.000	.873	47	.000

a. Lilliefors Significance Correction



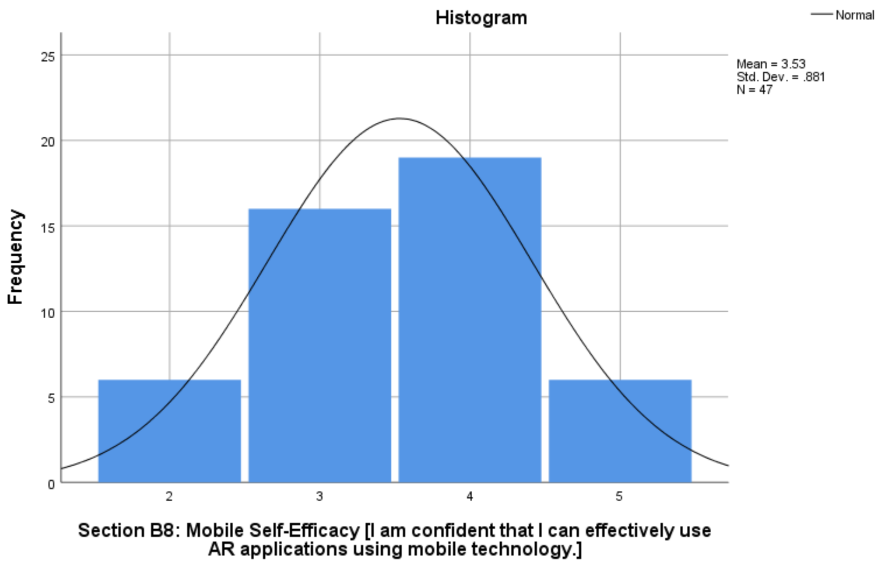
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 33

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B8: Mobile Self-Efficacy [I am confident that I can effectively use AR applications using mobile technology.]	.234	47	.000	.877	47	.000

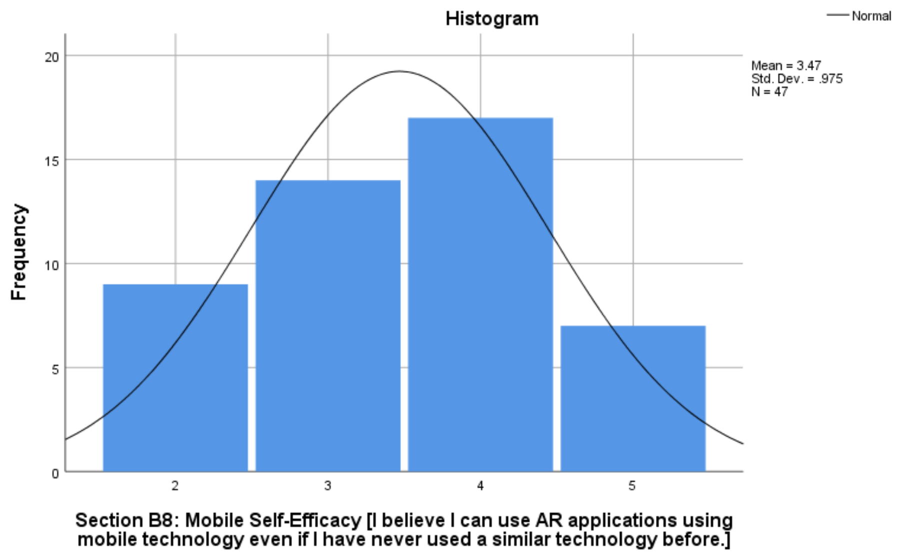
a. Lilliefors Significance Correction



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 34

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Section B8: Mobile Self-Efficacy [I believe I can use AR applications using mobile technology even if I have never used a similar technology before.]	.218	47	.000	.879	47	.000
a. Lilliefors Significance Correction						

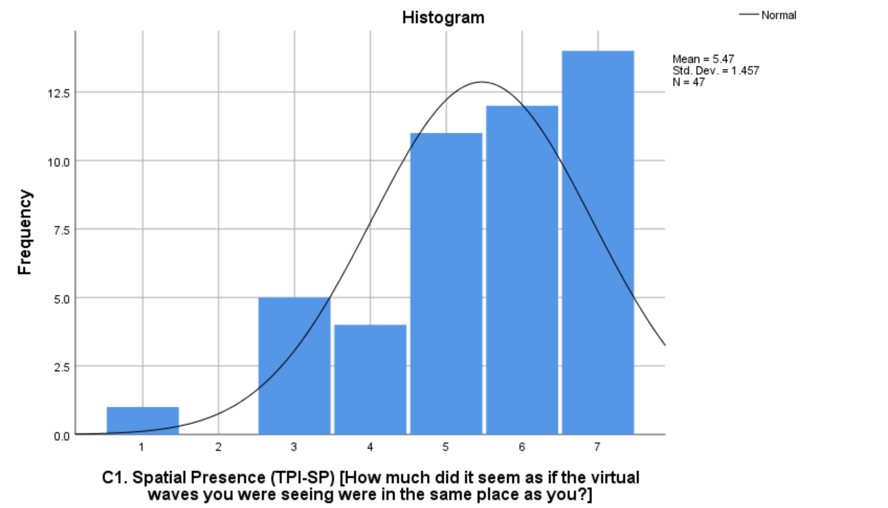


Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 35

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.

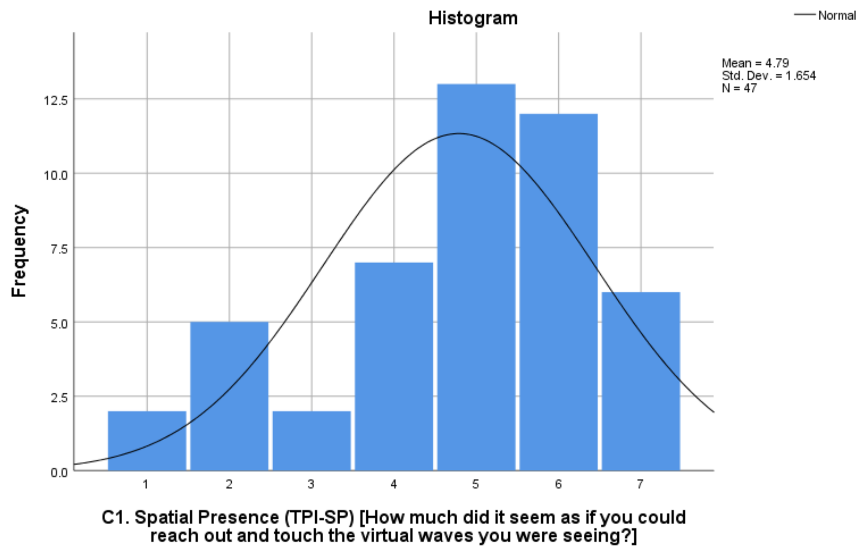
C1. Spatial Presence (TPI-SP) [How much did it seem as if the virtual waves you were seeing were in the same place as you?]	.196	47	.000	.872	47	.000
a. Lilliefors Significance Correction						



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 36

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1. Spatial Presence (TPI-SP) [How much did it seem as if you could reach out and touch the virtual waves you were seeing?]	.211	47	.000	.902	47	.001
a. Lilliefors Significance Correction						



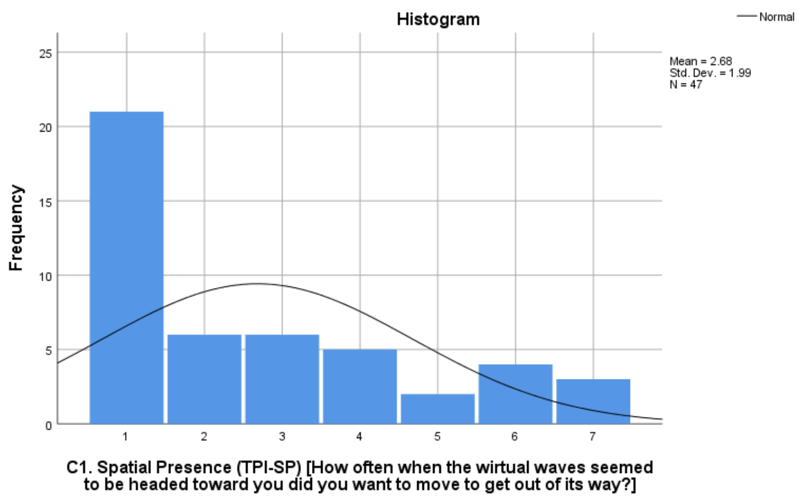
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 37

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1. Spatial Presence (TPI-SP) [How often when the wirtual waves seemed to be headed toward you did you want to move to get out of its way?]	.248	47	.000	.804	47	.000

a. Lilliefors Significance Correction



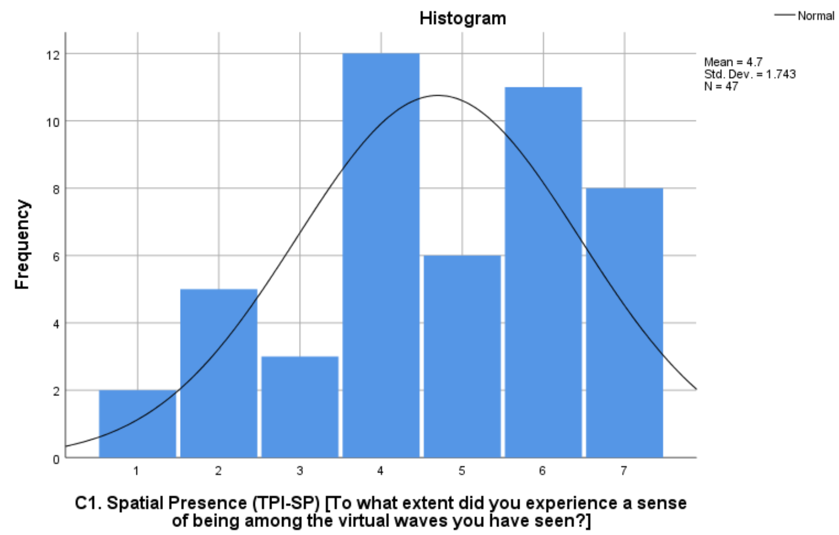
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

Variable 38

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1. Spatial Presence (TPI-SP) [To what extent did you experience a sense of being among the virtual waves you have seen?]	.176	47	.001	.919	47	.003

a. Lilliefors Significance Correction



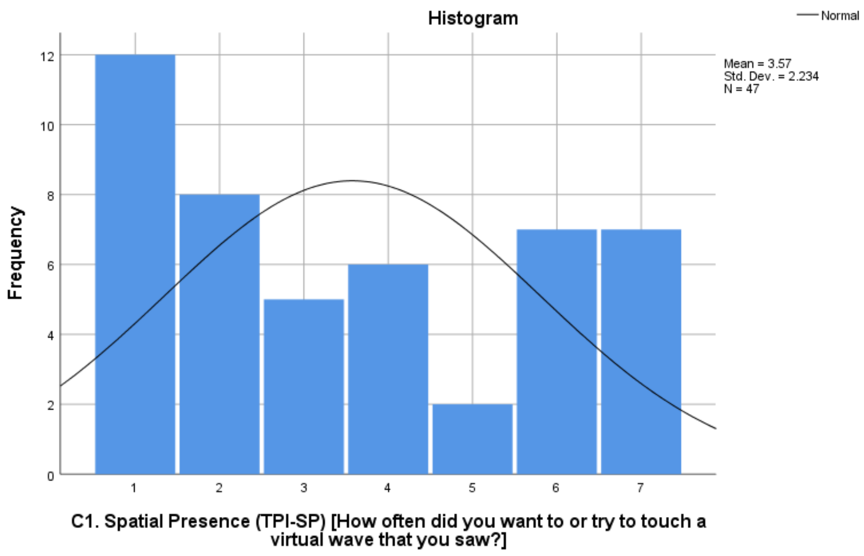
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

Variable 39

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1. Spatial Presence (TPI-SP) [How often did you want to or try to touch a virtual wave that you saw?]	.185	47	.000	.867	47	.000

a. Lilliefors Significance Correction



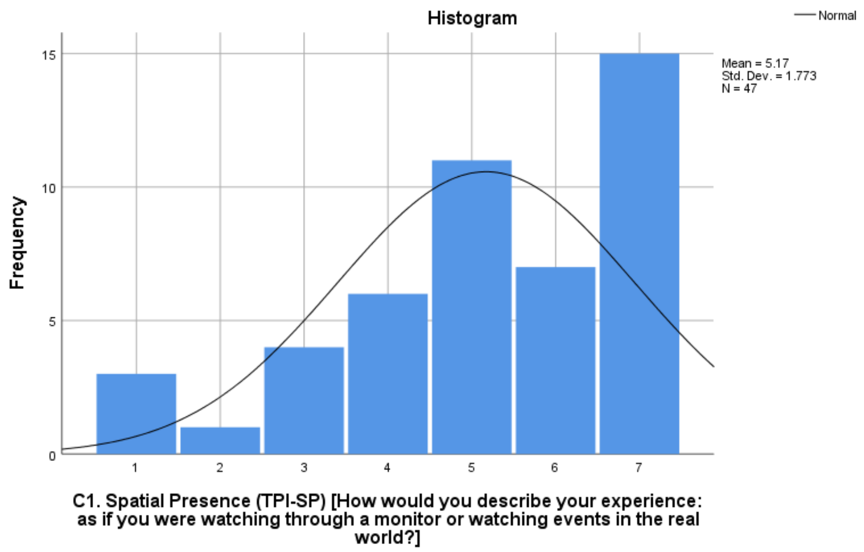
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed.

Variable 40

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1. Spatial Presence (TPI-SP) [How would you describe your experience: as if you were watching through a monitor or watching events in the real world?]	.168	47	.002	.871	47	.000

a. Lilliefors Significance Correction



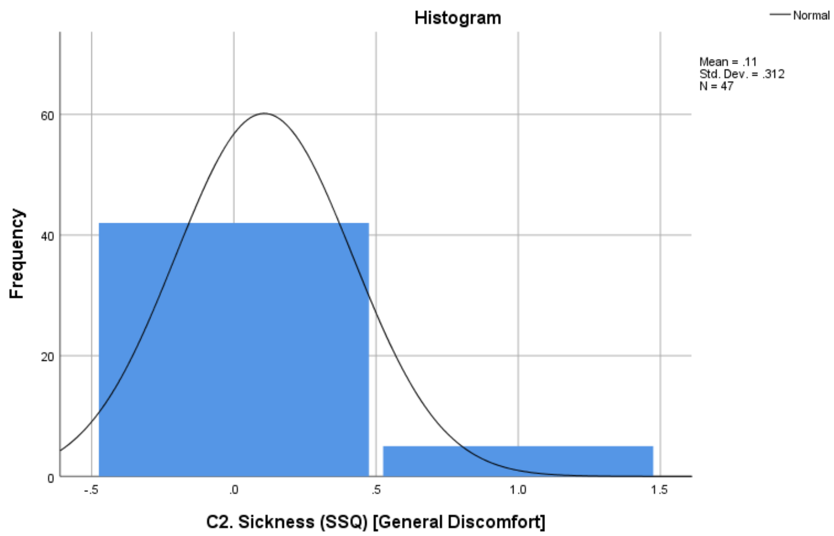
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the left.

Variable 41

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C2. Sickness (SSQ) [General Discomfort]	.527	47	.000	.356	47	.000

a. Lilliefors Significance Correction



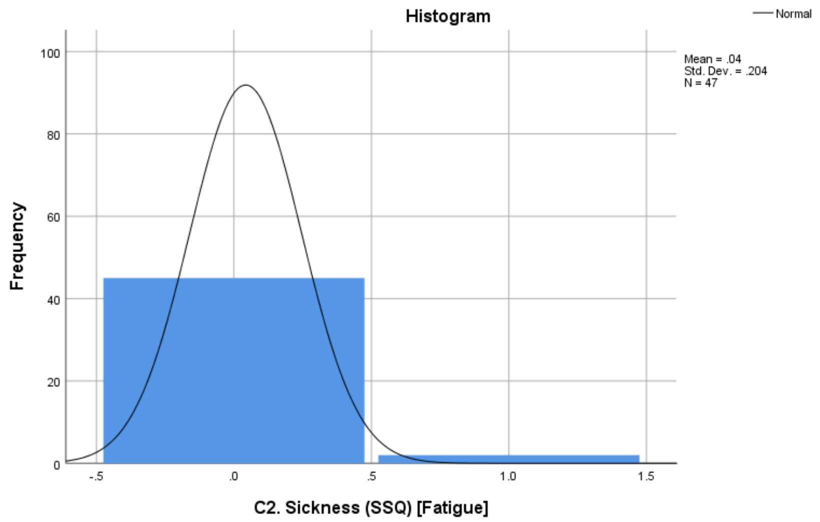
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

Variable 42

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C2. Sickness (SSQ) [Fatigue]	.540	47	.000	.206	47	.000

a. Lilliefors Significance Correction



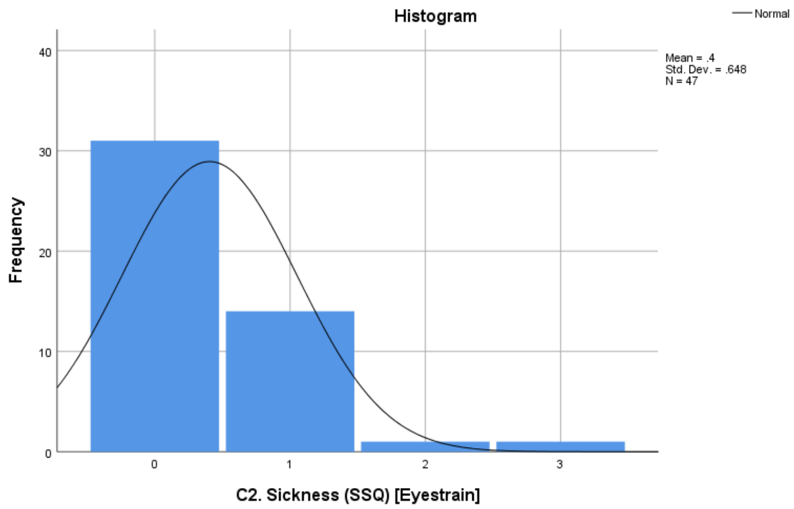
Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

Variable 43

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C2. Sickness (SSQ) [Eyestrain]	.393	47	.000	.634	47	.000

a. Lilliefors Significance Correction



Since the p-value of Kolmogorov Smirnov test is .000 (p-value < .05), we can say that the test is statistically significant and the values of this variable are not normally distributed. Apart from that histogram for the variable also indicates that values of the variables are not normally distributed rather they are skewed to the right.

APPENDIX C: REGRESSION ANALYSIS – TESTING OF ASSUMPTIONS

Checking Linearity between the Dependent Variables and the Independent Variables for the Augmented Reality dataset.

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating conditions

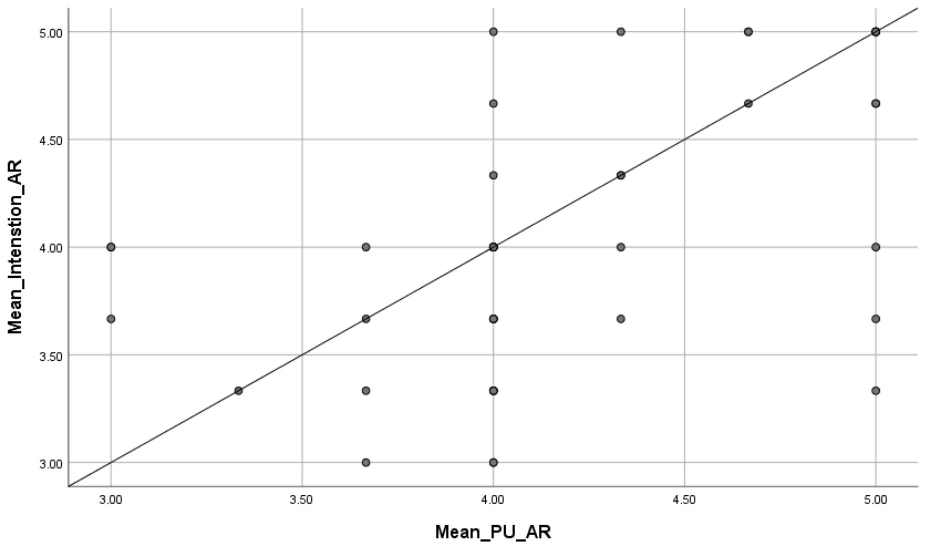


Figure 45. Scatter plot for Intention and Perceived Usefulness

According to Figure 45 the relationship between “Intention” and “Perceived Usefulness” is linear.

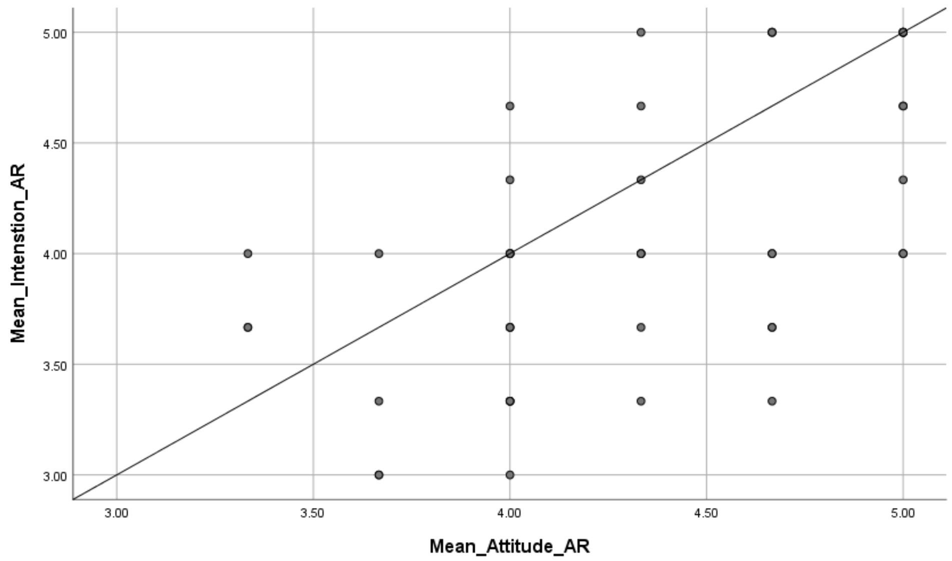


Figure 46. Scatter plot for Intention and Attitude

According to figure 46 the relationship between “Intention” and “Attitude” is linear.

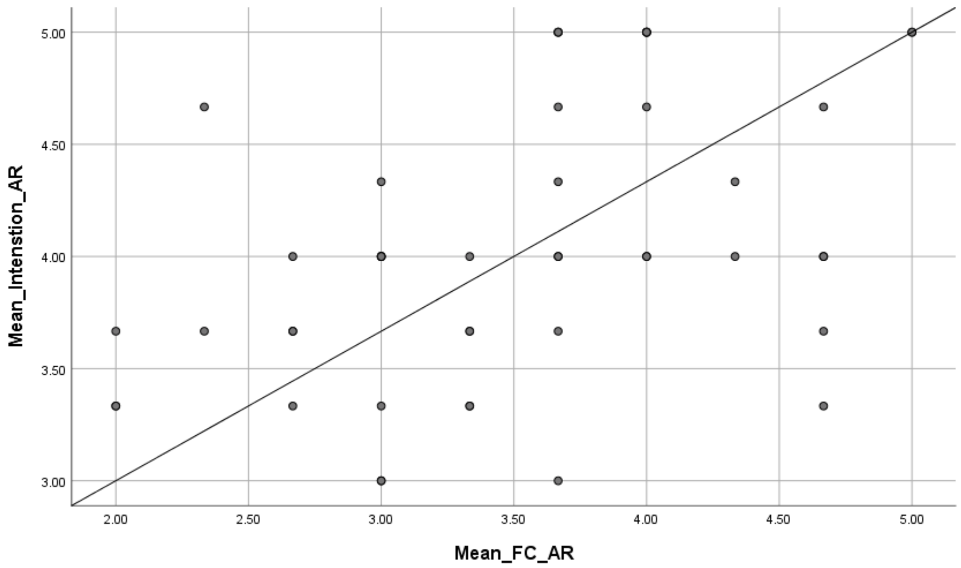


Figure 47. Scatter plot for Intention and Facilitating Conditions

According to figure 47 the relationship between “Intention” and “Facilitating Conditions” is linear.

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

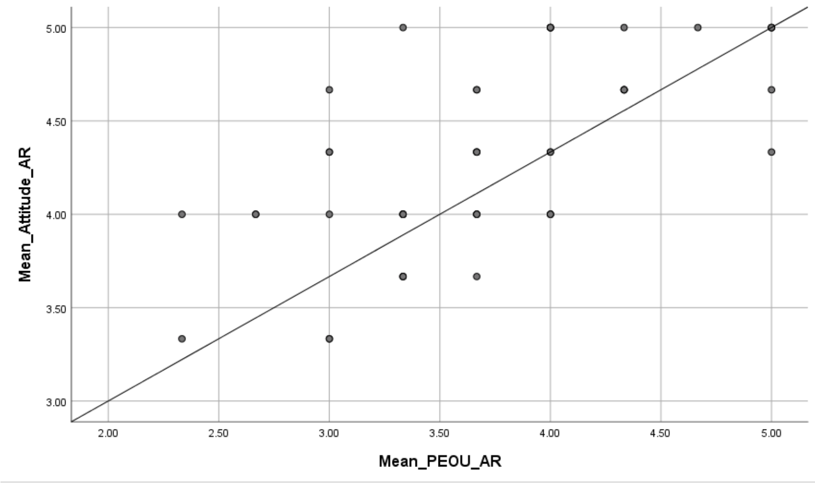


Figure 48. Scatter plot for Attitude and Perceived ease of use

According to figure 48 the relationship between “Attitude” and “Perceived Ease of Use” is linear.

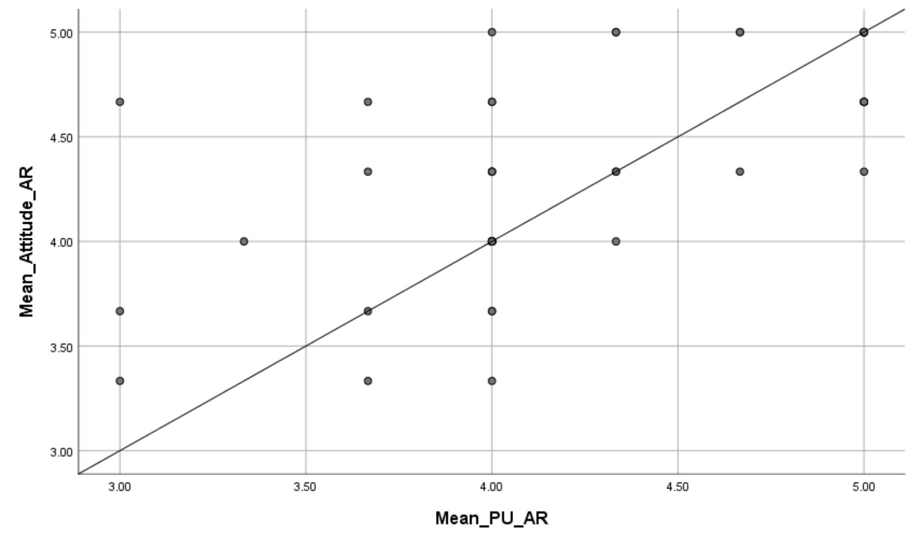


Figure 49. Scatter plot for Attitude and Perceived usefulness

According to figure 49 the relationship between “Attitude” and “Perceived Usefulness” is linear.

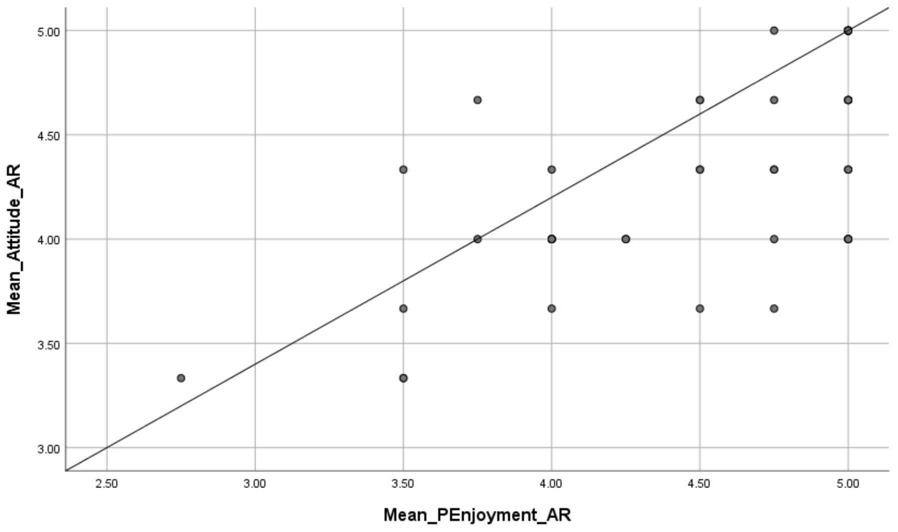


Figure 50. Scatter plot for Attitude and Perceived enjoyment

According to figure 50 the relationship between "Attitude" and "Perceived Enjoyment" is linear.

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- perceived enjoyment
- perceived ease of use

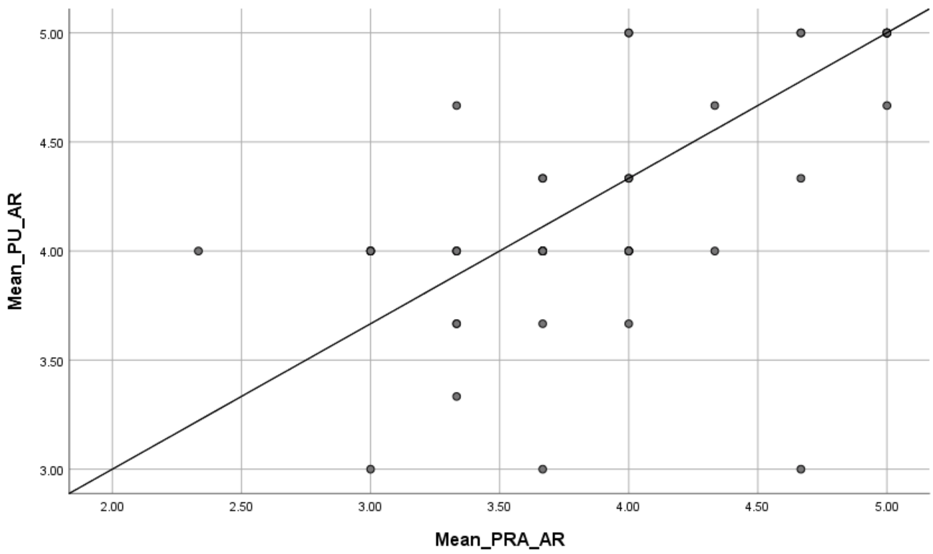


Figure 51. Scatter plot for Perceived Usefulness and Perceived relative advantage

According to figure 51 the relationship between "Perceived Usefulness" and "Perceived Relative Advantage" is linear.

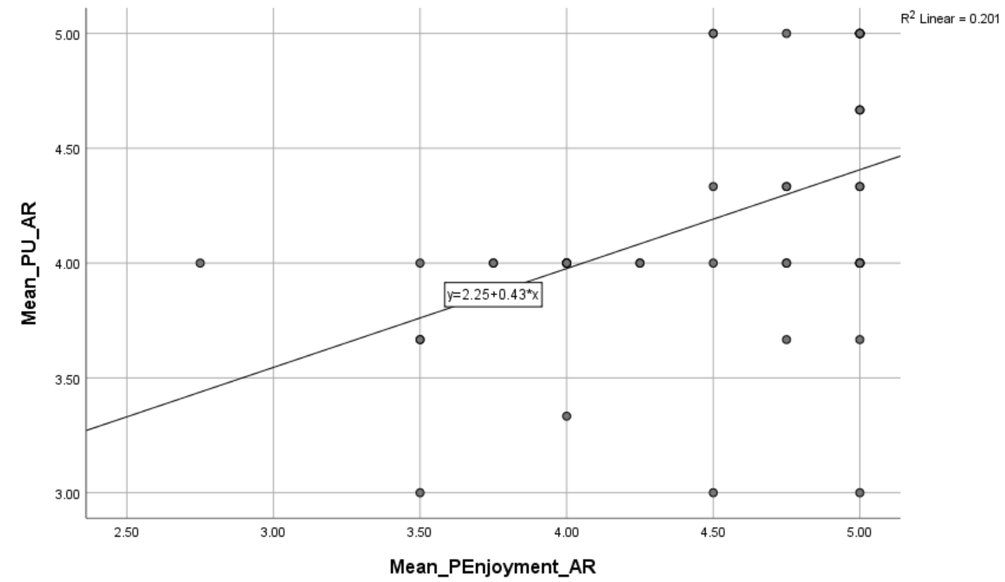


Figure 52. Scatter plot for Perceived Usefulness and Perceived enjoyment

According to figure 52 the relationship between “Perceived Usefulness” and “Perceived Enjoyment” is linear.

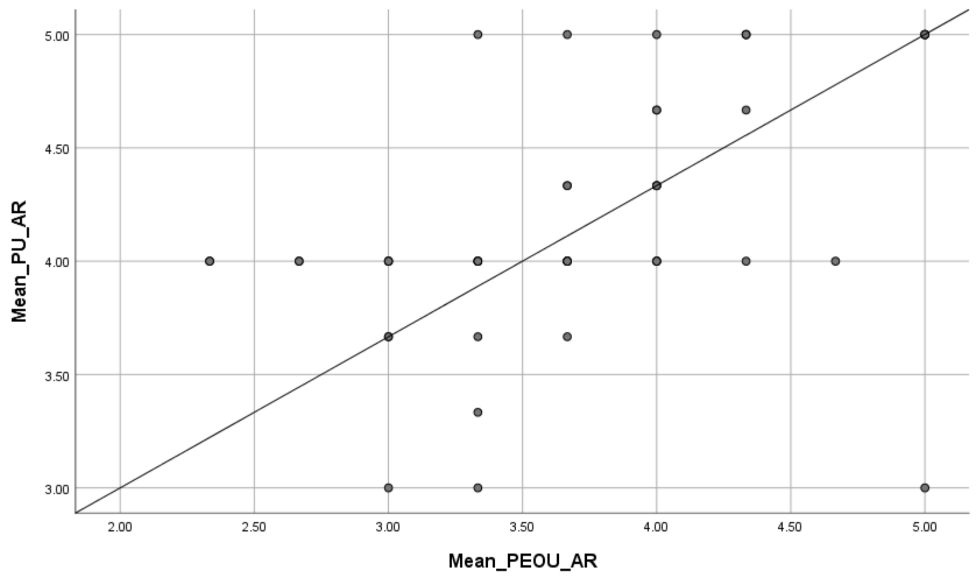


Figure 53. Scatter plot for Perceived Usefulness and Perceived ease of use

According to figure 53 the relationship between “Perceived Usefulness” and “Perceived Ease of Use” is linear.

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

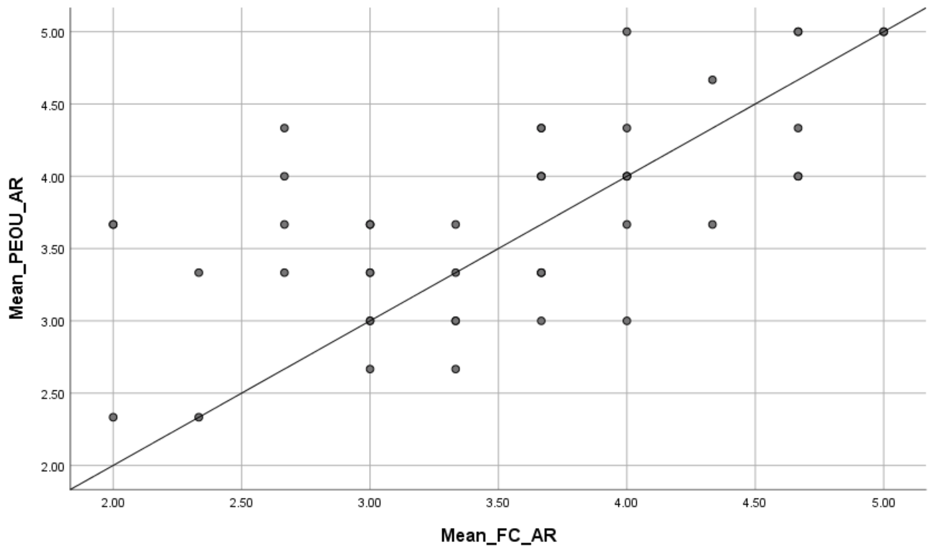


Figure 54. Scatter plot for Perceived ease of use and facilitating conditions

According to figure 54 the relationship between “Perceived Ease of Use” and “Facilitating Conditions” is linear.

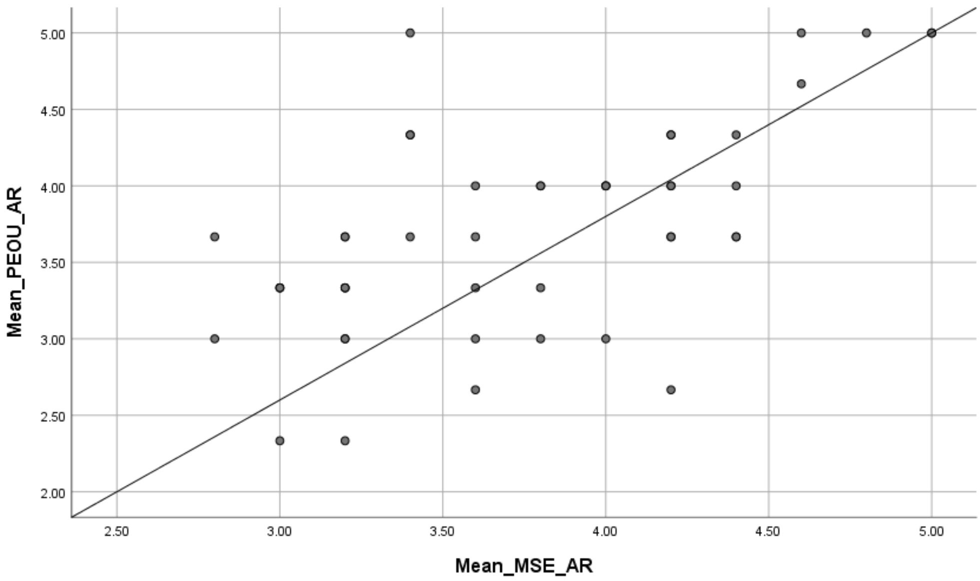


Figure 55. Scatter plot for Perceived ease of use and mobile self-efficacy

According to figure 55 the relationship between “Perceived Ease of Use” and “Mobile Self-efficacy” is linear.

Checking Linearity between the Dependent Variables and the Independent Variables for the Virtual Reality dataset

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating conditions

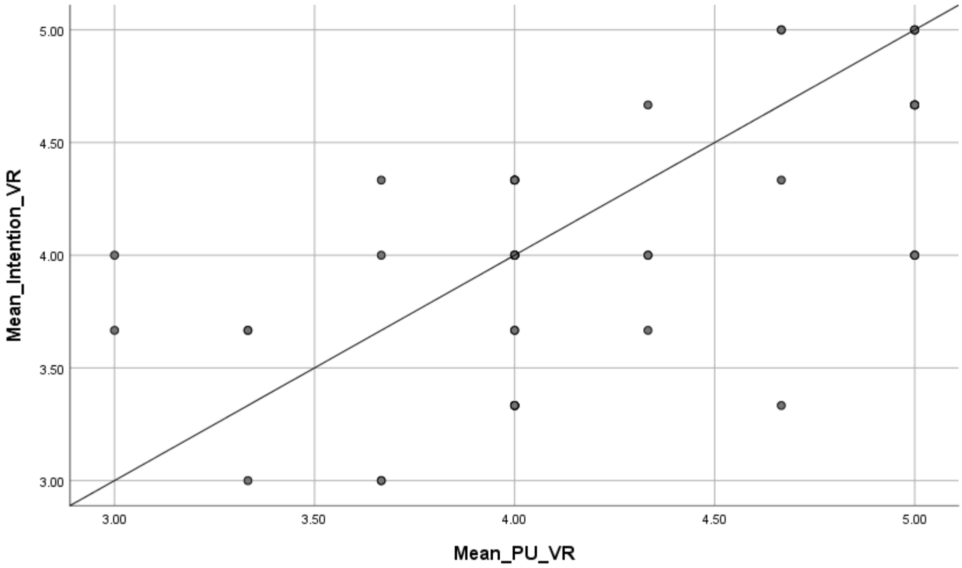


Figure 56. Scatter plot for Intention and Perceived Usefulness

According to figure 56 the relationship between "Intention" and "Perceived Usefulness" is linear.

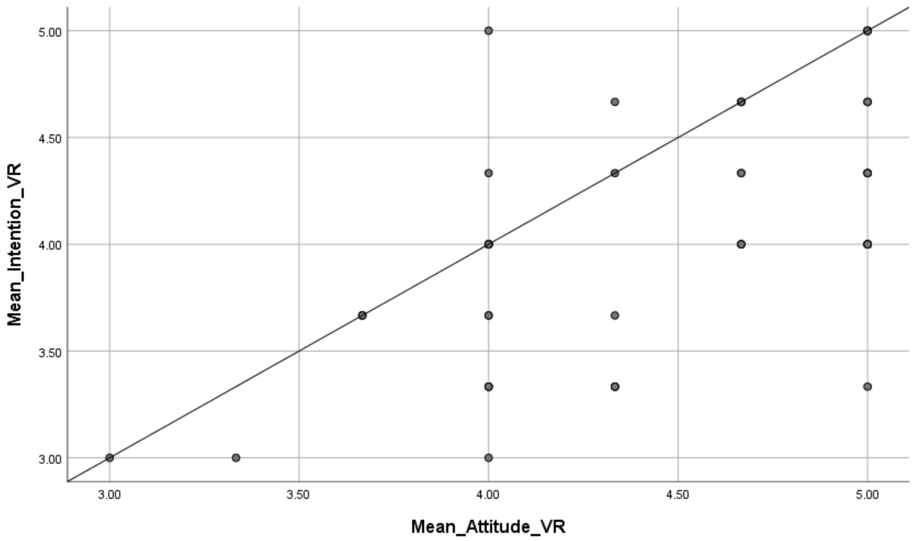


Figure 57. Scatter plot for Intention and Attitude

According to figure 57 the relationship between "Intention" and "Attitude" is linear.

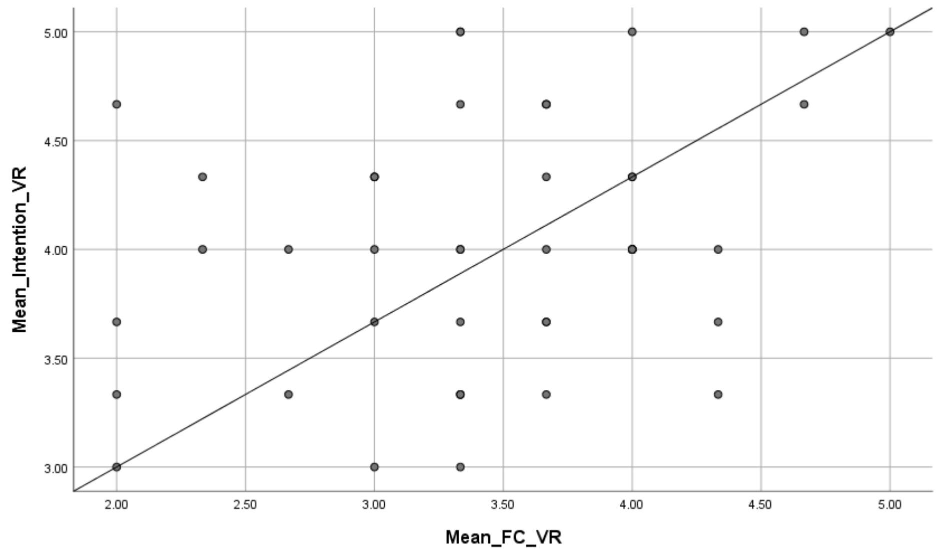


Figure 58. Scatter plot for Intention and facilitating conditions

According to figure 58 the relationship between "Intention" and "Facilitating Conditions" is linear.

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

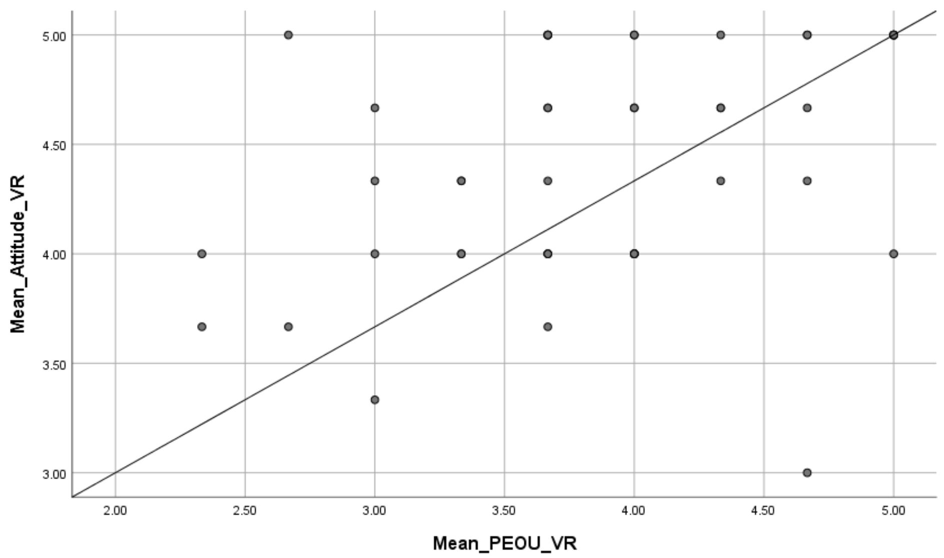


Figure 59. Scatter plot for Attitude and Perceived ease of use

According to figure 59 the relationship between "Attitude" and "Perceived Ease of Use" is linear.

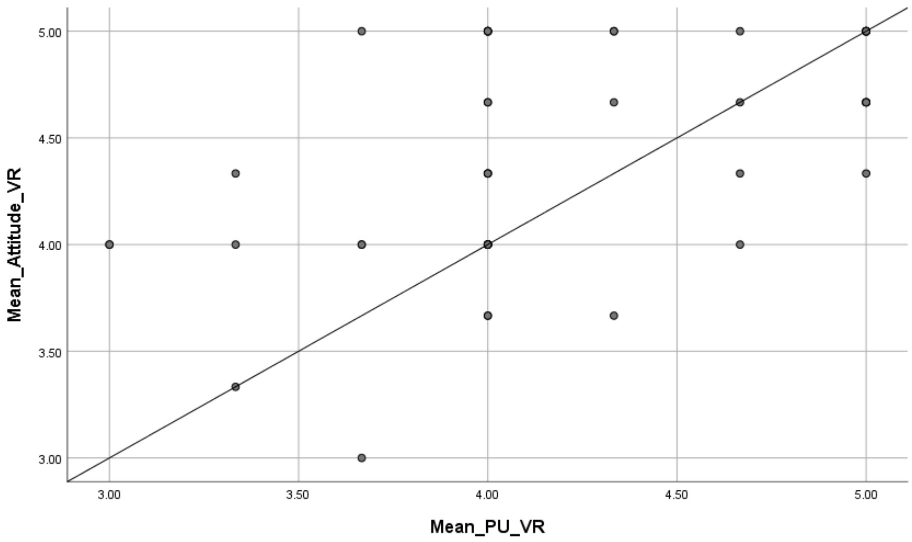


Figure 60. Scatter plot for Attitude and Perceived usefulness

According to figure 60 the relationship between "Attitude" and "Perceived Usefulness" is linear.

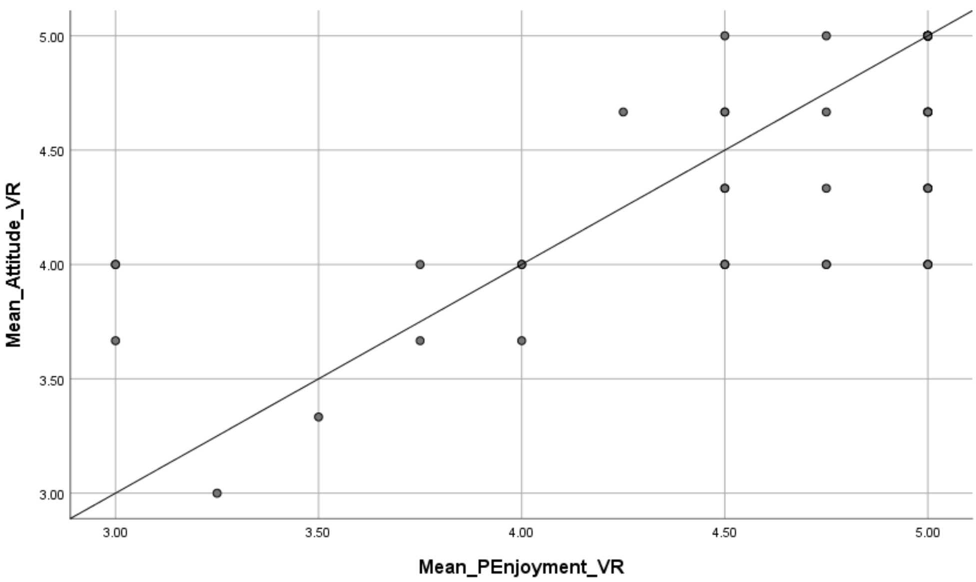


Figure 61. Scatter plot for Attitude and Perceived enjoyment

According to figure 61 the relationship between "Attitude" and "Perceived Enjoyment" is linear.

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- Perceived enjoyment
- Perceived ease of use

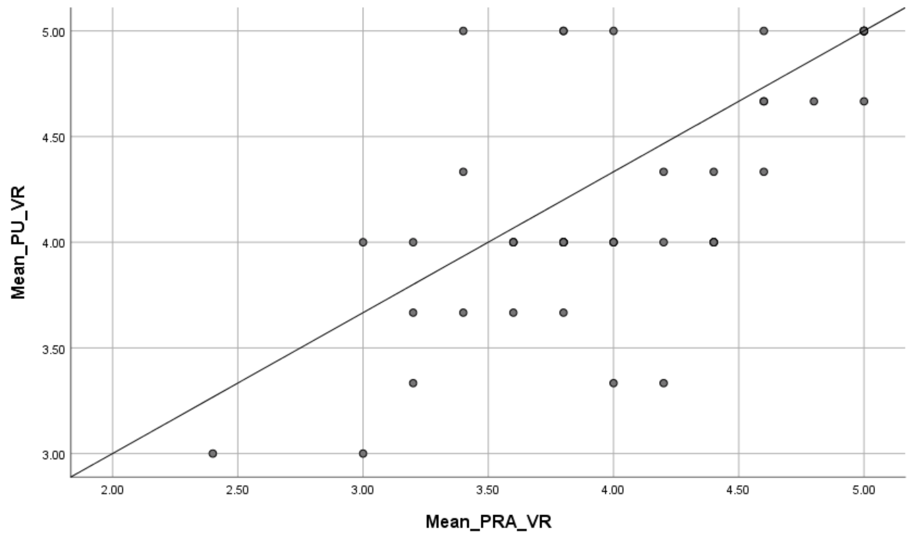


Figure 62. Scatter plot for Perceived Usefulness and Perceived relative advantage

According to figure 62 the relationship between “Perceived Usefulness” and “Perceived Relative Advantage” is linear.

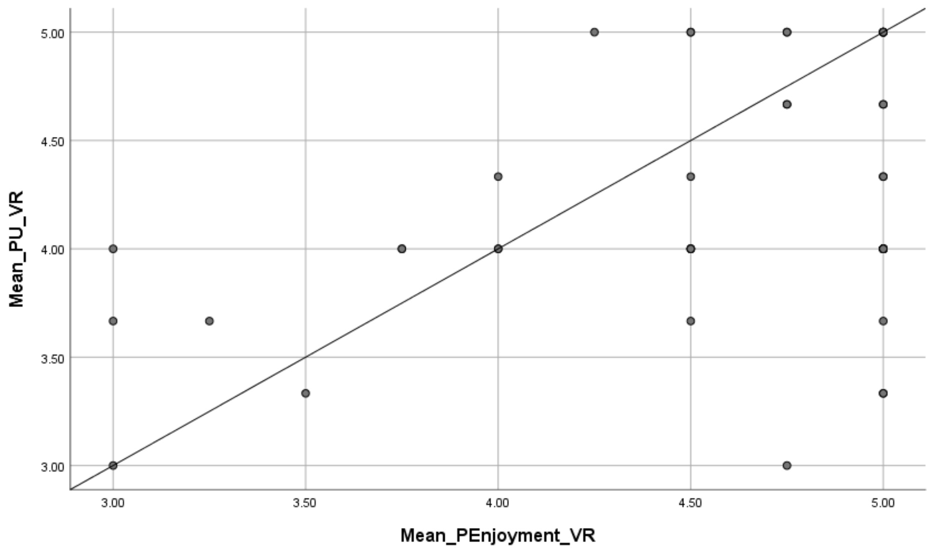


Figure 63. Scatter plot for Perceived Usefulness and Perceived enjoyment

According to figure 63 the relationship between “Perceived Usefulness” and “Perceived Enjoyment” is linear.

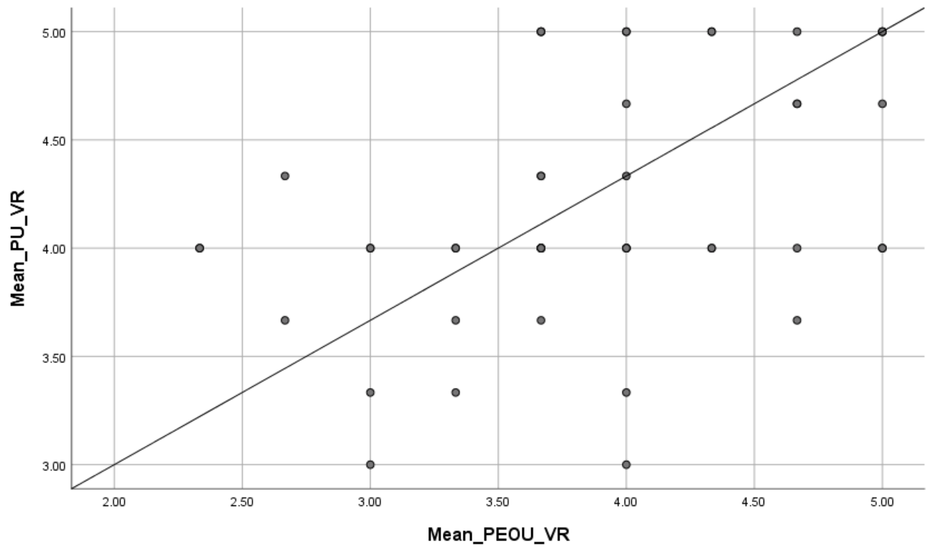


Figure 64. Scatter plot for Perceived Usefulness and Perceived ease of use

According to figure 64 the relationship between "Perceived Usefulness" and "Perceived Ease of Use" is linear.

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

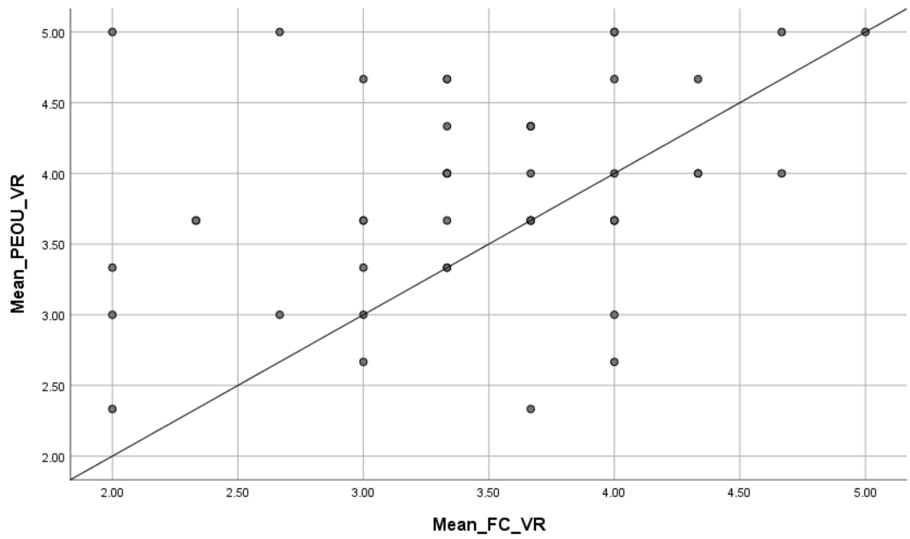


Figure 65. Scatter plot for Perceived ease of use and facilitating conditions

According to figure 65 the relationship between "Perceived Ease of Use" and "Facilitating Conditions" is linear.

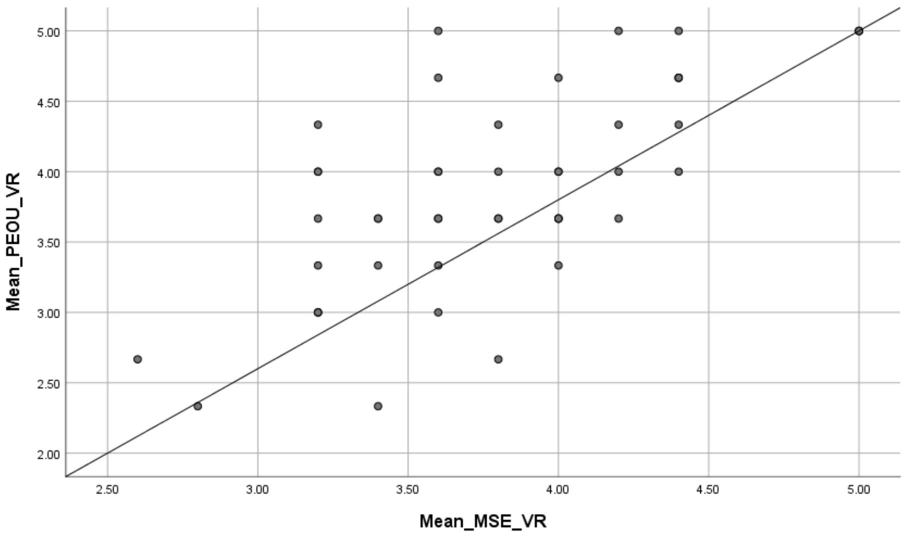


Figure 66. Scatter plot for Perceived ease of use and mobile self-efficacy

According to figure 66 the relationship between "Perceived Ease of Use" and "Mobile Self-efficacy" is linear.

Homoscedasticity in the Augmented Reality dataset

Following it will be examined if there is homoscedasticity in the dependent variables and the independent variables of the Augmented Reality dataset.

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating condition

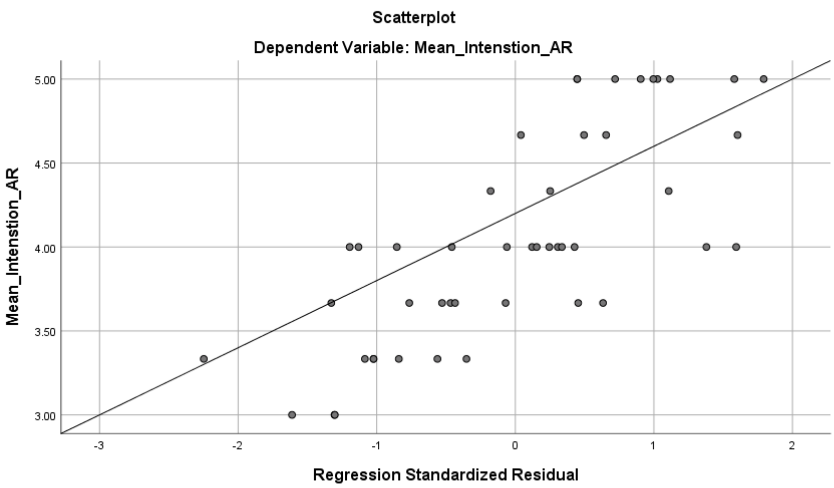


Figure 67. Scatter plot for “Intention”, “Perceived usefulness”, “Attitude”, and “Facilitating condition”

In figure 67, the y-axis contains the dependent variable “Intention” and the x-axis contains the independent variables “Perceived usefulness”, “Attitude”, and “Facilitating condition”. According to figure 67 there is no homoscedasticity in the variables.

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

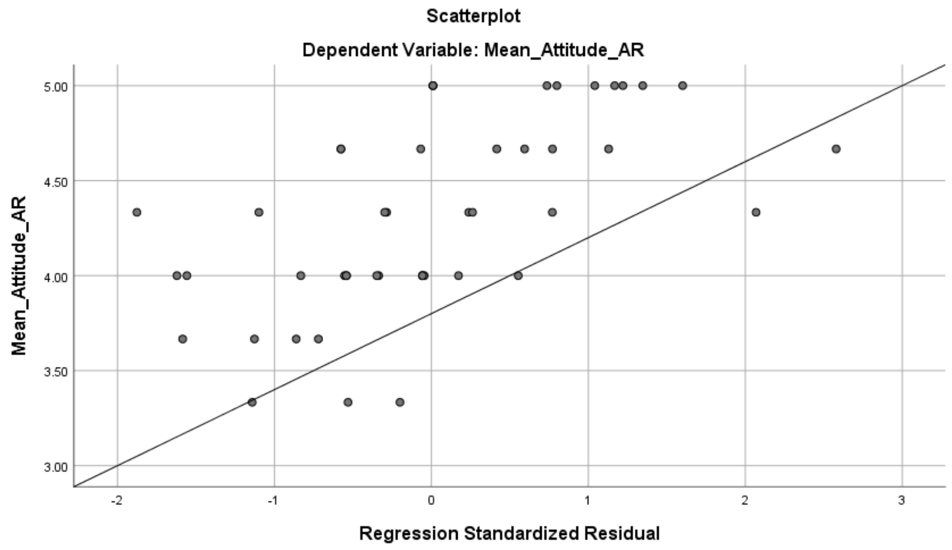


Figure 68. Scatter plot for “Attitude”, “Perceived ease of use”, “Perceived usefulness”, and “Perceived enjoyment”

In figure 68, the y-axis contains the dependent variable “Attitude” and the x-axis contains the independent variables “Perceived ease of use”, “Perceived usefulness”, and “Perceived enjoyment”. According to figure 68 there is no homoscedasticity in the variables.

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- perceived enjoyment
- Perceived ease of use

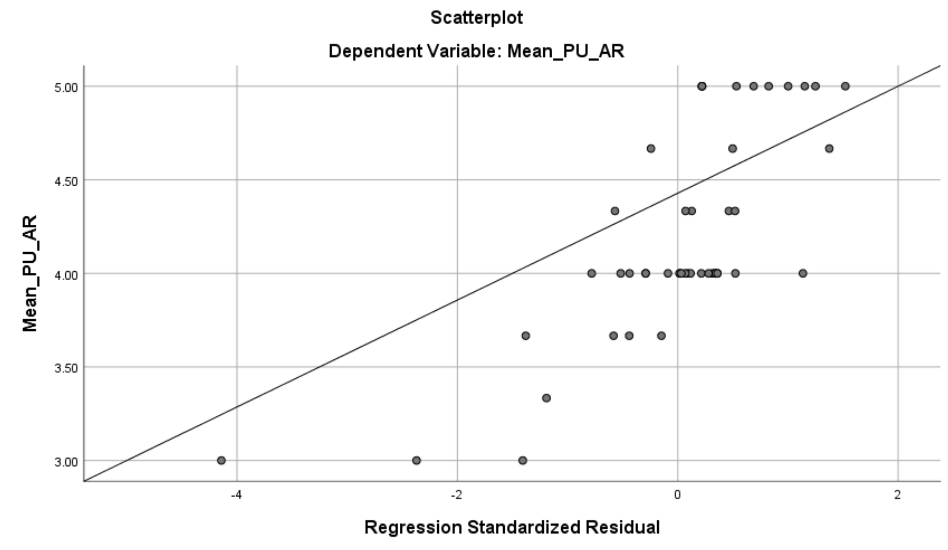


Figure 69. Scatter plot for “Perceived usefulness”, “Perceived relative advantage”, “Perceived enjoyment”, and “Perceived ease of use”

In figure 69, the y-axis contains the dependent variable “Perceived usefulness” and the x-axis contains the independent variables “Perceived relative advantage”, “Perceived enjoyment”, and “Perceived ease of use”. According to figure 69 there is no homoscedasticity in the variables.

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

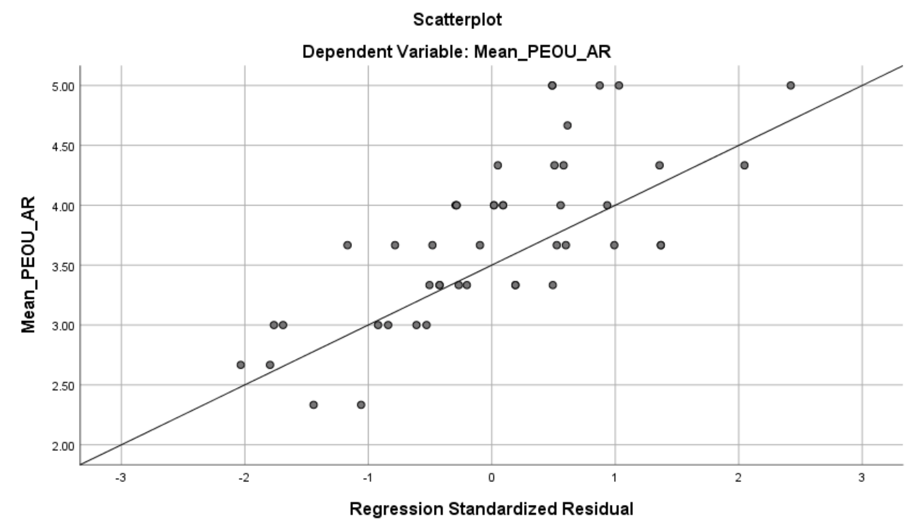


Figure 70. Scatter plot for “Perceived ease of use”, “Facilitating conditions” and “Mobile self-efficacy”

In figure 70, the y-axis contains the dependent variable "Perceived ease of use" and the x-axis contains the independent variables "Facilitating conditions" and "Mobile self-efficacy". According to figure 70 there is no homoscedasticity in the variables.

Homoscedasticity in the Virtual Reality dataset

Following it will be examined if there is homoscedasticity in the dependent variables and the independent variables of the Virtual Reality dataset.

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating condition

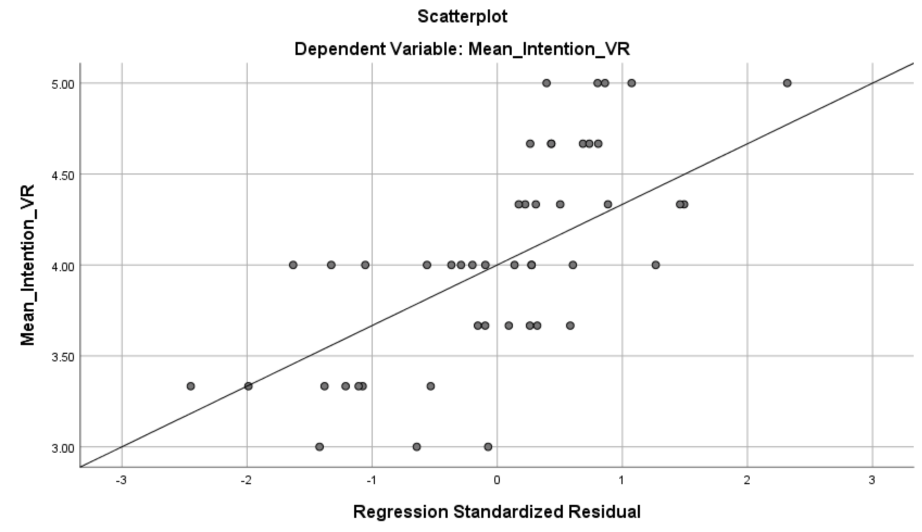


Figure 71: Scatter plot for "Intention", "Perceived usefulness", "Attitude", and "Facilitating condition"

In figure 71, the y-axis contains the dependent variable "Intention" and the x-axis contains the independent variables "Perceived usefulness", "Attitude" and "Facilitating condition". According to figure 71 there is no homoscedasticity in the variables.

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

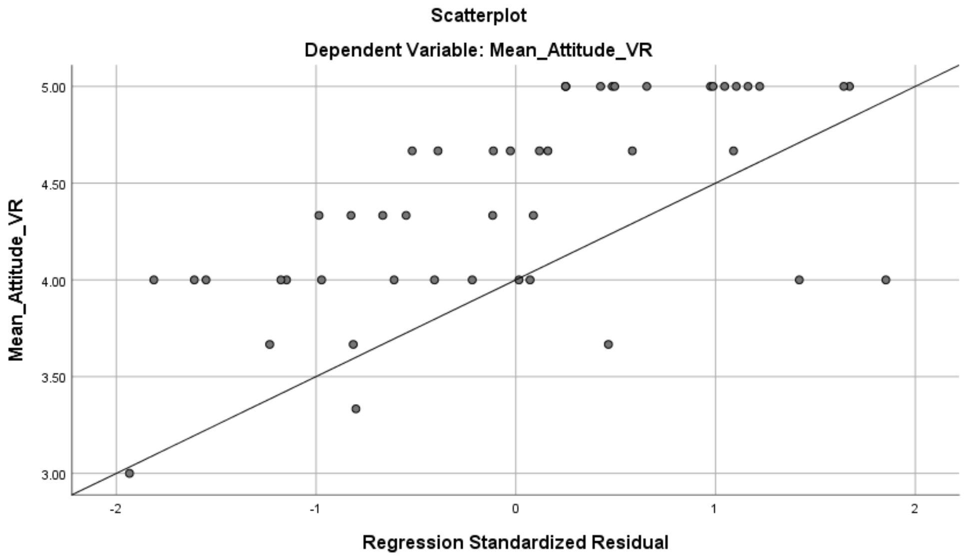


Figure 72: Scatter plot for “Attitude”, “Perceived ease of use”, “Perceived usefulness”, and “Perceived enjoyment”

In figure 72, the y-axis contains the dependent variable “Attitude” and the x-axis contains the independent variables “Perceived ease of use”, “Perceived usefulness” and “Perceived enjoyment”. According to figure 72 there is no homoscedasticity in the variables.

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- perceived enjoyment
- Perceived ease of use

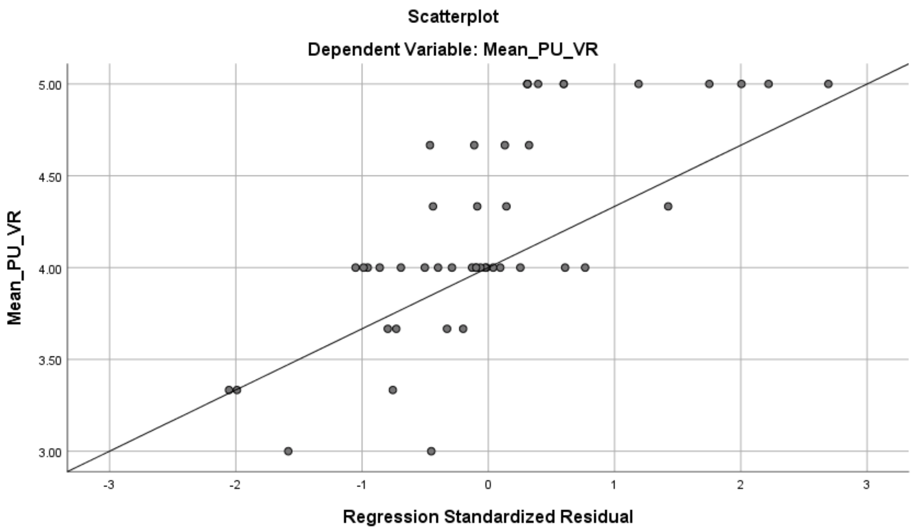


Figure 73: Scatter plot for “Perceived usefulness”, “Perceived relative advantage”, “Perceived enjoyment”, and “Perceived ease of use”

In figure 73, the y-axis contains the dependent variable “Perceived usefulness” and the x-axis contains the independent variables “Perceived relative advantage”, “Perceived enjoyment” and “Perceived ease of use”. According to figure 73 there is no homoscedasticity in the variables.

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

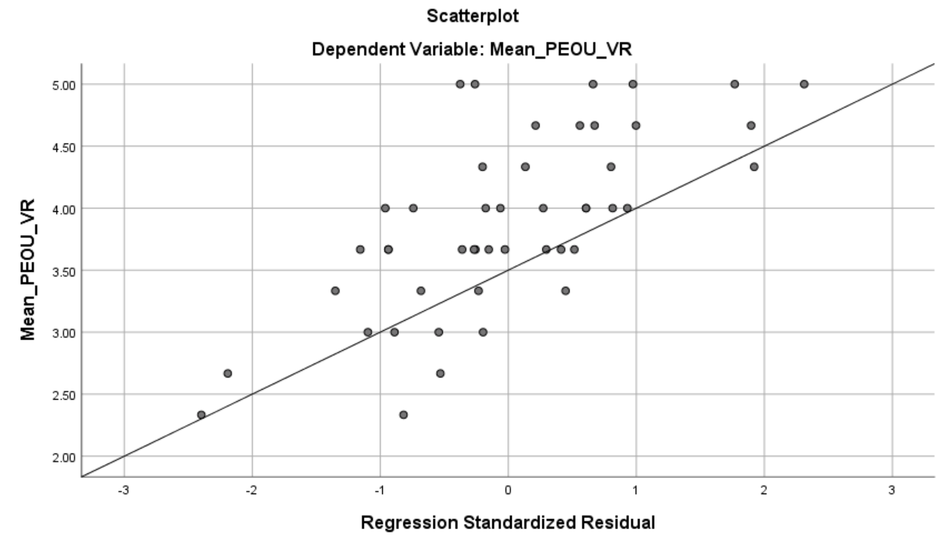


Figure 74: Scatter plot for “Perceived ease of use”, “Facilitating conditions” and “Mobile self-efficacy”

In figure 74, the y-axis contains the dependent variable “Perceived ease of use” and the x-axis contains the independent variables “Facilitating conditions” and “Mobile self-efficacy”. According to figure 74 there is no homoscedasticity in the variables.

Multicollinearity in predictors of the Augmented Reality dataset

Following it will be examined if there is Multicollinearity in the dependent variables and the independent variables of the Augmented Reality dataset.

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating condition

Table 98: Multicollinearity for “Perceived usefulness”, “Attitude”, and “Facilitating condition”

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	Perceived Usefulness	.599	1.671
	Attitude	.520	1.924
	Facilitating Conditions	.725	1.380
a. Dependent Variable: Intention			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 98).

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

Table 99: Multicollinearity for “Perceived ease of use”, “Perceived usefulness”, and “Perceived enjoyment”

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	Perceived ease of use	.662	1.511
	Perceived usefulness	.712	1.404
	Perceived enjoyment	.687	1.455
a. Dependent Variable: Attitude			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 99).

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- perceived enjoyment
- Perceived ease of use

Table 100: Multicollinearity for “Perceived relative advantage”, “Perceived enjoyment”, and “Perceived ease of use”

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	Perceived relative advantage	.735	1.360
	Perceived enjoyment	.645	1.551
	Perceived ease of use	.714	1.400
a. Dependent Variable: Perceived Usefulness			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 100).

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

Table 101: Multicollinearity for "Facilitating conditions" and "Mobile self-efficacy"

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	Facilitating conditions	.560	1.785
	Mobile self-efficacy	.560	1.785
a. Dependent Variable: Perceived ease of use			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in predictors (table 101).

Multicollinearity in predictors of Virtual reality dataset

Following it will be examined if there is Multicollinearity in the dependent variables and the independent variables of the Virtual Reality dataset.

Dependent Variable

- Intention

Independent Variables

- Perceived usefulness
- Attitude
- Facilitating condition

Table 102: Multicollinearity for "Perceived usefulness", "Attitude", and "Facilitating condition"

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Perceived usefulness	.723	1.384
	Attitude	.707	1.414
	Facilitating condition	.966	1.035
a. Dependent Variable: Intention			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 102).

Dependent Variable

- Attitude

Independent Variables

- Perceived ease of use
- Perceived usefulness
- Perceived enjoyment

Table 103: Multicollinearity for "Perceived ease of use", "Perceived usefulness", and "Perceived enjoyment"

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Perceived ease of use	.792	1.262
	Perceived usefulness	.761	1.315
	Perceived enjoyment	.837	1.195
a. Dependent Variable: Attitude			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 103).

Dependent Variable

- Perceived Usefulness

Independent Variables

- Perceived relative advantage
- perceived enjoyment
- Perceived ease of use

Table 104: Multicollinearity for "Perceived relative advantage", "Perceived enjoyment", and "Perceived ease of use"

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Perceived relative advantage	.610	1.640

	Perceived enjoyment	.689	1.452
	Perceived ease of use	.793	1.260
a. Dependent Variable: Perceived Usefulness			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 104).

Dependent Variable

- Perceived ease of use

Independent Variables

- Facilitating conditions
- Mobile self-efficacy

Table 105: Multicollinearity for "Facilitating conditions" and "Mobile self-efficacy"

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	Facilitating conditions	.943	1.060
	Mobile self-efficacy	.943	1.060
a. Dependent Variable: Perceived ease of use			

Since the VIF values for all predictors are less than 3, we conclude that there is no Multicollinearity in the predictors (table 105).