School of Information Systems

Developing, Understanding and Evaluating an Augmented Reality Framework for Universities in Saudi Arabia

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This thesis is presented for the Degree of
Doctor of Philosophy
Of
Curtin University

July 2020

DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # **HRE2017-0425**

Signature:

Date:22/07/2020

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful Alhamdulillah, all praises to Allah for the strengths given and His blessing in completing this thesis.

My first tribute goes to my PhD supervisor, Dr Tomayess Issa, without whom the completion of this thesis would have been impossible. I would like to gratefully and sincerely thank her for her trust in me as her PhD student, her guidance, understanding, patience, helpful comments and her illustrations on earlier drafts. I appreciate her help that, from the initial to the final level, enabled me to develop an understanding of the subject.

I am also thankful to Dr Theodora Issa and Dr S Zaung Nau for their encouragement, support and professional guidance throughout my study and publications. They gave me detailed and comprehensive feedback about my PhD, which assisted me on this journey. It is difficult to overstate my gratitude to my parents for supporting me through my PhD years. Without them, none of this would even be possible. You have always been my biggest enthusiasts, and I appreciate that. My special gratitude is due to my wife Mariam for standing with me and encouraging me to achieve my study's goals. Thanks, my beloved wife, without your encouragement, support, understanding, patience, caring and listening, writing this thesis would not have been possible. My little angel Sarah, you were my smile during the busiest and hardest time. No words in any language can express my heartfelt thanks to my lovely family for their kindness and thoughtfulness during this long journey. I would also like to thank my brother and sisters for keeping me motivated and for providing me with some memorable experiences.

I would like to thank my friends for all the good and bad times we had together here in Perth, Australia. My thanks to everyone who contributed to my study, and I will be at a loss if I do not mention the participants, without whom the research would not be achievable. I am grateful to have a scholarship from the Imam Abdulrahman bin Faisal University, and I would like to say thank you for providing me with the opportunity to be where I am. Finally, thank you for every single person who has supported and encouraged me to achieve this point.

ABSTRACT

Currently, technology plays a significant role in the education sector in improving and enhancing students' professional and personal skills that are needed for the workforce. Technology has introduced new tools such as Augmented Reality (AR), that blends three-dimensional virtual objects with reality, and these technologies can be used as a learning tool. Literature acknowledges that AR as a learning tool is an effective method of motivating students, increasing their level of engagement, and improving their learning outcomes. Yet, research on AR adoption in developing countries, particularly Saudi Arabia as an oil producer, with their 2030 vision to reduce oil dependencies and improve public sectors, including education, in performance and spending efficiency, is scarce. A limited body of research has examined which factors are required for the successful adoption of innovative technologies such as AR in Saudi Arabian universities to achieve its 2030 vision of excellence in technology implementation and resolve the problems associated with the current higher education system. Also, the lack of relevant frameworks and guidelines that might support the successful and effective technology integration in the Saudi context is a concern. Therefore, this research aims to bridge these research gaps identified by providing an AR framework and recommendations as a blueprint to guide the Saudi universities in successful and efficient AR integration.

After an initial holistic AR framework was first derived from the literature review, the study applied an explanatory, sequential mixed-method design comprising two phases of data collection, with priority placed on quantitative methods. First, the study conducted a quantitative survey to validate initial factors and provide an improved list of factors/sub-factors for the AR framework. An online survey was administrated with a sample population of 729 (501 students, 228 academic and e-learning staff) from Saudi Arabian universities. For this study, quantitative data were collected utilising a questionnaire where participants responded to statements on a five-point Likert scale that ranged from "strongly agree" to "strongly disagree". The exploratory factor analysis technique was utilised to reflect a consistent interpretation of the survey data, unlike the original groupings, and determine the final number of factors to be considered, and therefore, included in the final framework. The data analysis resulted in extracted factor loadings, eigenvalues, and a scree plot that indicated fundamental

factors in the survey. These factors illustrated outstanding factor loadings (.4 lowest to .9 highest). The results further refined the AR framework with factors derived from three sources (students, academics and e-learning staff). All the initial factors were retained as well as changes made to the factor's name, numbers, and sub-factors based on survey analysis. The findings of this phase were used to enhance the framework and examine it through qualitative online semi-structured interviews conducted in non-real-time with potential users of the framework to ensure the effectiveness of the final framework.

Finally, the survey results constituted the basis for the interview phase. Online semi-structured interviews were carried out with 19 interviewees that are experts in AR development and educational technology specialists, to confirm and evaluate the final set of factors and discuss quantitative results in more detail while incorporating literature. The target population for this study was drawn from universities and institutions in Saudi Arabia. Ultimately, the thematic analysis of interview data identified a set of factors which are considered as critical for AR adoption and were added to the AR framework. The final framework integrated the survey results with all key factors, while further improvements in the main factors and related sub-factors captured the findings of crucial interviews. The final framework also saw the introduction of the pedagogy factor, which suggested the significance of this dimension as a steppingstone towards incorporating AR technology within the Saudi educational context.

The study makes two main contributions. First, the study provides a framework of critical success factors for AR integration in Saudi Arabian universities. It aligns with the Saudi Government's 2030 vision to have at least five Saudi universities competing with the world's top universities in international rankings, through the adoption of technological innovations such as AR. Second, the implications of this research study provided a quantitative and qualitative indicator of the perceptions and awareness of Saudi Arabia's higher education universities of the potential use of AR. While this study was limited to the perceptions of Saudi Arabian universities' students, lecturers, e-learning staff, educational technology personnel, and AR experts, this study's findings, the framework and recommendations, provide guidelines as to which factors need to be considered to implement AR technology successfully for stakeholders who had never considered nor integrated an AR tool. The findings of this research can be generalised to other developing countries with similar higher education and socio-cultural environments. Developed countries may also benefit from the results of this research in pursuit of the implementation of AR or other similar technologies in university environments. In addition, further research could involve widening the research context to evaluate the same framework in other developed countries in order to determine if the framework can be broadened by taking more factors into account.

However, this research had several limitations, and there are areas of improvement. Data from an exploratory source were difficult for the researcher to find because AR is still a new technology, and some of the participants were not familiar with it. Further research may build on the findings of this research to explore the use and efficacy of AR in Saudi universities through experiential data from academic staff and the perspectives of students. Further research may be conducted to analyse and test the factor relationship using various methodologies and methods, such as structural equation modelling and SmartPLS. In addition, further research could involve widening the research context to evaluate the same framework in other developed countries in order to determine if the framework can be broadened by taking more factors into account.

Published work

1. **Alahmari, M**. (2019). Students' Awareness of Augmented Reality Adoption in Saudi Arabia Universities *Australasian Conference on Information Systems, held in Perth Western Australia,* (pp. 21-31). acis.

2. **Alahmari, M**., Issa, T., Issa, T., & Nau, S. Z. (2019). Faculty awareness of the economic and environmental benefits of augmented reality for sustainability in Saudi Arabian universities. *Journal of Cleaner Production, 226*, 259-269.

3. **Alahmari, M**. S. (2018). *Developing, Understanding and Evaluating Augmented Reality Framework for Universities in Saudi Arabia*. Paper presented at the eLmL 2018, The Tenth International Conference on Mobile, Hybrid, and Online Learning, Rome, Italy.

4. Abu-Salih, B., Bremie, B., Wongthongtham, P., Duan, K., Issa, T., Chan, K. Y., ... & **Alahmari, M**. (2019). *Social Credibility Incorporating Semantic Analysis and Machine Learning: A Survey of the State-of-the-Art and Future Research Directions*. In Workshops of the International Conference on Advanced Information Networking and Applications (pp. 887-896). Springer, Cham.

Memberships

- Member of the Technical Program Committee in WWW2017: Sustainability and Smart Technology Workshop (SST2017).

- A reviewer of WWW2017: Sustainability and Smart Technology Workshop (SST2017)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1. The Introduction

1.1 Introduction

An enormous number of growing technologies have been getting a strong reaction in recent years. Applications of emerging technologies are changing our education, health care and business processes for the better. Before introducing these technologies into mainstream education, it is essential to research and conceptualise the latest technologies with appropriate pedagogies (Hantono et al., 2018). Langlie (2008) points out that new learning is shifting from the information age to the conceptual age. As Warren, Lee, and Najmi (2014, p. 92) explain, to prepare learners to be meaning makers, applying strategies and tools are required to make them ready for the real world "as we shift to a new age of conceptual learning, a determination must be made of what a learning environment that includes these characteristics should look like." The objective is to add materials and information to the teaching setting that is not easily accessible elsewhere (Balkun, 2011). The adoption of advanced technologies in the field of education is considered as one of the recent revolutions, which can include learners of all ages and needs.

In the area of learning, the increased learning demands, and enhanced learning outcomes, have precipitated many issues in the academic curriculum at the universities. Consequently, it is more challenging to use traditional methods of learning to convey the teaching content such as constructive knowledge, theoretical-practical, and functional to the students. Integrating technology in the field of teaching and learning has been recently increased to enhance students' knowledge and ability to learn (Oliver et al., 2012). AR technology has become a popular research topic and has been widely explored and used in many settings, including learning. For the past two decades, AR is one of these new technologies that will undoubtedly have a high level of introduction into all educational context, including universities and the expected time to adopt this technology in higher education is two to three years from now (Alexander et al., 2019). The effectiveness of these tools inspires these technologies to be used in the higher education sector (Johnson et al., 2016). For example, many institutes use AR to enhance traditional learning methods (Kamarainen et al., 2013; Martín-Gutiérrez et al., 2010; Martín-Gutiérrez et al., 2012; Tarng & Ou, 2012). As will be outlined in section 2.3.5.3, the use of these technologies enables the process of learning to be active, motivating, meaningful, and attractive to the students and teachers (Nischelwitzer et al., 2007). AR allows users to interact with virtual objects in the real world with more natural interactions (Neale et al., 2011). AR is already involved in the majority of the social, gaming, end-user, and location-based applications (Johnson et al., 2010). AR has gained much consideration in studies in recent years.

The Gartner Hype Cycle for Emerging Technologies chart (see Figure 1 underneath) indicates the future of AR, where it was in 2006 and where it is today. Figure 1 shows the rapid movement of AR technology through the Hype Cycle, and AR almost reached the bottom. AR begins to grow and gain traction in the third stage because more companies see the value of using AR (Gartner, 2019). Vogt and Shingles (2013, p. 57) stated, "AR is an emerging concept, but it is now transitioning to a more firmly established technology." According to International Data Corporation (IDC, 2019), AR is one of the top eight crucial, fast-growing technologies from more than 150 emerging technologies in 2019, with world market growth estimated at US $5.2 billion in 2016 to more than $18.8 billion by 2020 (De PaceManuri & Sanna, 2018).

Furthermore, while completing this thesis, the world was hit by the COVID-19 pandemic, which has had an unprecedented effect on global business. According to Rygol (2020), utilising AR can help minimise the societal and business impact while promoting business processes through the pandemic. AR can enhance remote assistance with a live video-sharing experience between two or more people, unlike traditional videoconferencing. McMahon (2020) points out that AR, with its vast potential, can be the solution for many companies and originations to achieve COVID-19 recovery and future productivity.

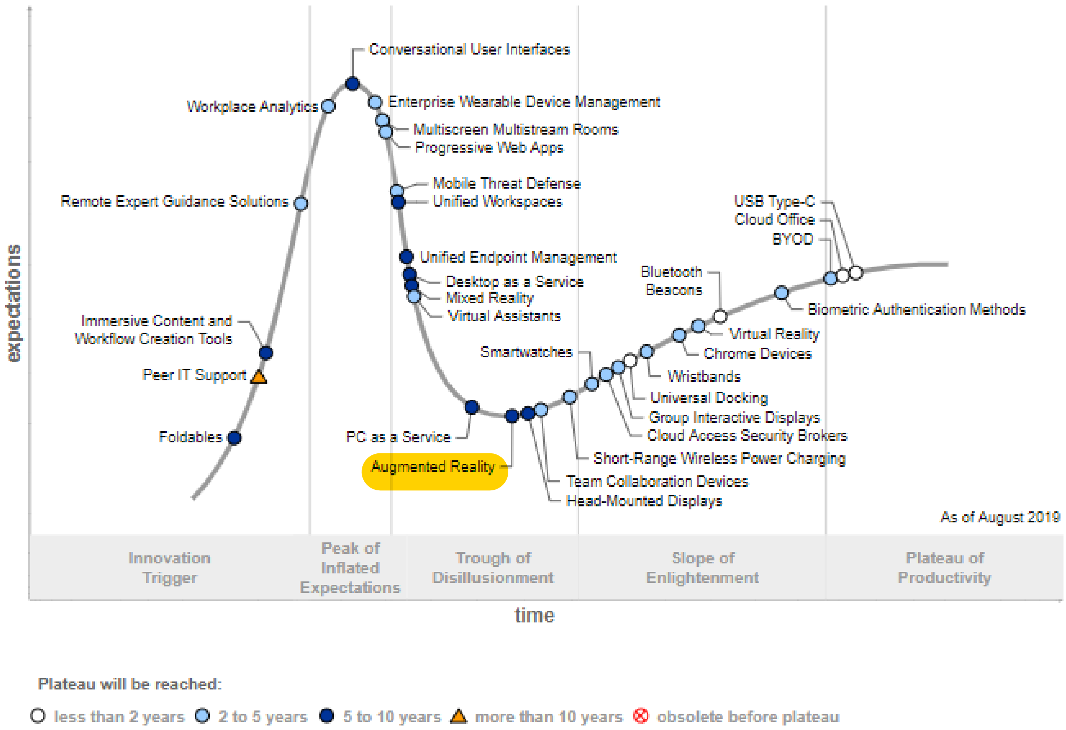


Figure 1: Hype Cycle for Mobile, Endpoint and Enterprise Wearable Computing (Gartner, 2019).

Also, Coie (2018) found that investing in AR in education ranked third after gaming and medical services and was expected to get as much as 26% of the total AR investment in 2022. Education around the world has undergone a significant transformation as a result of the COVID-19 pandemic, and technology has been used quickly and creatively to maintain teaching and learning. Adopting new technologies such as AR during the COVID-19 pandemic can benefit practical teaching in higher education (Pacheco, Noll, & Mendonça, 2020). Likewise, Krishnamurthy (2020) sees AR as a solution to enhance remote teaching with an immersive experience and interaction during the quarantine.

However, Oliver et al. (2012) indicated that the ideal adoption of technology in the learning environment is yet to be achieved. Thus, research on the potential factors that could lead to restrictions on ICT adoption and achieve desirable changes in learning quality has become a common field of research (Alkhattabi, 2017; Ćukušić, Alfirević, Granić & Garača, 2010; Gayol, 2010). In particular, the success and further integration of digital learning initiatives in the education context are based on the conceptual basis for its use and integration into education (Barroso-Osuna et al., 2019). Although literature abounds in identifying factors to use these technologies (Barroso-Osuna et al., 2019; Naidu, 2004), limited work has been done to determine factors for incorporating AR, especially in developing states like Saudi Arabia (SA). SA's government places particular emphasis on the development of the higher education system in its 2030 vision and want to ensure that technology is an integral part of the educational goal, to be internationally recognised and classified (Salameh, 2016). Nevertheless, the factors of AR integration continue to be mostly unexplored in universities in SA and representation remains sparse at the university level with little to no guidance on integrating AR applications.

This research aims to contribute conceptually to AR literature and make a practical contribution to SA university environments. Developing an AR framework for Saudi universities will make a conceptual contribution, which can be used in other developing countries with universities similar to that in SA. The practical contribution includes recommendations for key university stakeholders for future implementation of AR at Saudi universities. With this research in mind, it is essential to note that currently, there is a lack of theoretical and validated frameworks that guide AR adoption in Saudi Arabian (SAn) higher education. It is envisioned that this framework will assist Saudi universities in maximising their theoretical and academic knowledge of the critical factors necessary for successful implementation of AR in teaching and learning approaches in universities. Also, the outcomes of this research might help Saudi Arabian universities by raising the current understanding of how AR be used practically to maintain education in the COVID-19 pandemic or any global pandemic.

1.2 Virtual Reality (VR) and Augmented Reality (AR)

Virtual Reality (VR) is defined by McLellan (1996, p. 461.) as “a class of computer-controlled multisensory communication technologies that allow more intuitive interactions with data and involve human senses in new ways.” McGlashan and Axling (1996) elucidated that virtual reality is a graphical two or three-dimensional interface that enables the communication between the user and computer while AR is the next step of VR. Ronald Azuma (1997) identified the good points of using an AR system which has three characteristics: mixes real and virtual; interactive in the real world; and registers in 3-D. Total immersion is provided in the VR environment while AR integrates the information in user's existing view. In order to process the scene, the VR system presents an entirely artificial environment, whereas AR processes the information from different resources and superimposes it onto the users' environment (Johnson et al., 2008). Nevertheless, involvement, navigation, and interaction are common features that AR and VR share (Di Serio, Ibáñez, & Kloos, 2013).

A study has been conducted by Huang et al. (2019) to address the gap in the literature by comparing AR and VR technologies with regard to their impact on learning outcomes, AR has been found to be a more effective way to transmit audio information through the spatial process of existence, possibly due to increased cognitive demands associated with immersive experiments. More discussion about the affordances of AR in education is illustrated in section 2.3.5.3. Therefore, this research is limited and concentrated more on AR than VR.

1.3 Definition of Augmented Reality

AR is an integration of digital information with the user environment in real-time. It is a variation of Virtual Reality (VR) (Azuma, 1997). It was defined by Azuma et al. (2001) as a system that enhances the real world with artificial objects by computer-generated sensory input such as graphics, video sound, or Global Positioning System (GPS) data. The information is superimposed from different resources into the users' environment. AR "consists of merging live images with virtual layers of information" (Vogt & Shingles, 2013, p. 47). The ability of AR in merging both the physical and the digital increases the perceptions of users and predicts a significant increase in the integration of AR in various areas of life (Bullhound, 2018). In 1997, a survey about AR was written by Ronald Azuma to define the AR. Azuma's (1997) survey identified the excellent points of using an AR system which has these characteristics:

- Integrates the real and virtual.
- Interactive in the real world.
- Registered in 3-D.
- High level of interactivity.
- Sensory input is used such as sound, video, graphics, or GPS-data.
- Supports spatial registration (in any sensory dimension).

The survey outcomes indicated that, due to the many obstacles and unexplored paths in this field, AR would remain a vibrant research field for several years. AR has two modes that are available for educators (Johnson et al., 2010; Lee, 2012):

- **Marker-based AR or vision-based AR:** this type of AR presents virtual objects and digital media (i.e., text, 3D models, graphics, video, and audio) to the users when they point a camera to a visual marker (e.g. 2D target, QR code). The identification of the location of 3D objects on a real-world image requires specific labels (Johnson et al., 2010). Figure 2 illustrates the concept of marker-based AR. AR uses a software application to recognise images such as a QR or a physical object and then generates the augmented virtual content and overlays this information onto the recognised object (Cheng & Tsai, 2013).

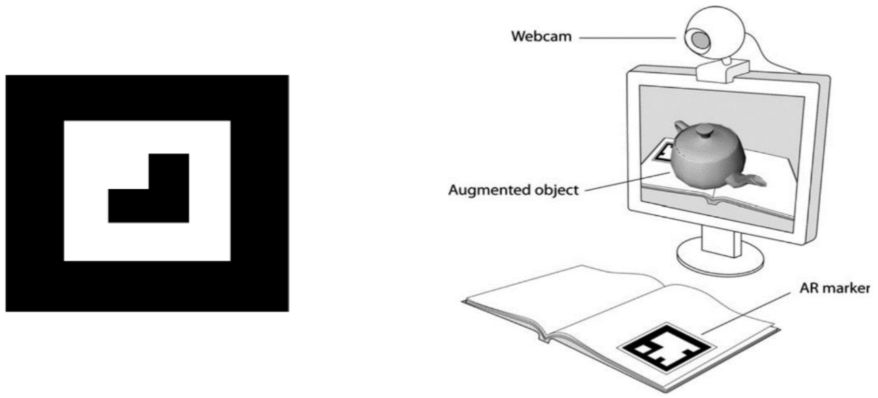


Figure 2. The concept of Marker-based AR (Cheng & Tsai, 2013, p. 451)

Figure 3 demonstrates a flowchart of a basic marker-based system of the AR system. An image is taken from the camera in the capturing module. For virtual overlay, the tracking module determines the right location and orientation. The rendering unit uses the measured location to merge the original image and the digital elements, and then the augmented image can be viewed (Siltanen, 2012).

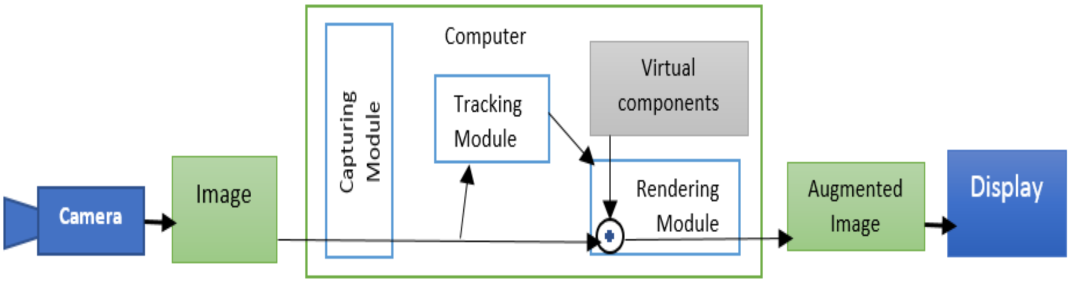


Figure 3: AR Marker-based AR architecture (Siltanen, 2012, p. 20) (Prepared by author)

- **Markerless AR or Location-based**: according to Lee (2012) markerless AR finds the users' location such as via GPS, and then the application integrates the virtual content on an exact location on or within the users' real environment (see Figure 4).

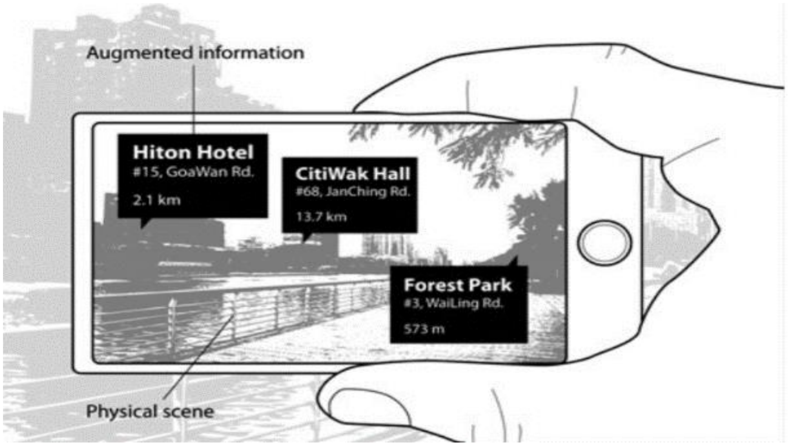


Figure 4: Markerless AR or Location aware (Cheng & Tsai, 2013, p. 452)

The digital data in location-based AR are connected to a particular location for an instant. For example, information about restaurants around the users or information about public transportation, are constructed in virtual spaces and linked to physical locations (Lee, 2012). Software for mobile devices can be used to access this information when users are at the physical location. First, Point of Interests (POI) or references in the physical map need to be defined, and then virtual assets such as text, video, and 3D will be combined onto that POI. Location-based AR works when users explore the location by using the appropriate application on their mobile devices (Cheng and Tsai, 2013). These applications reveal the POIs and examine the content. Using location-based AR content became much more comfortable with the popularity of tablets, smartphones and web services. Users can create their own "layer" or "channels" and post personal media as the social web (Peddie, 2017).

Vogt and Shingles (2013, p. 47) described the differences between the two types of AR, "Location-based AR applications rely on the spatial position and orientation of the device to select and display location-relevant information. For image-based AR, applications use image recognition algorithms to trigger the display of relevant content over a recognised physical pattern". According to Cheng and Tsai (2013), the difference between these types is that they use different techniques of recognition, Marker-based AR or vision-based AR depending on original graphics or artificial labels. In contrast, Markerless AR uses a wireless network or GPS to register users' positions and superimpose the information into the users' environment based on his/her location (Peddie, 2017). Figure 5 illustrates the differences between these types.

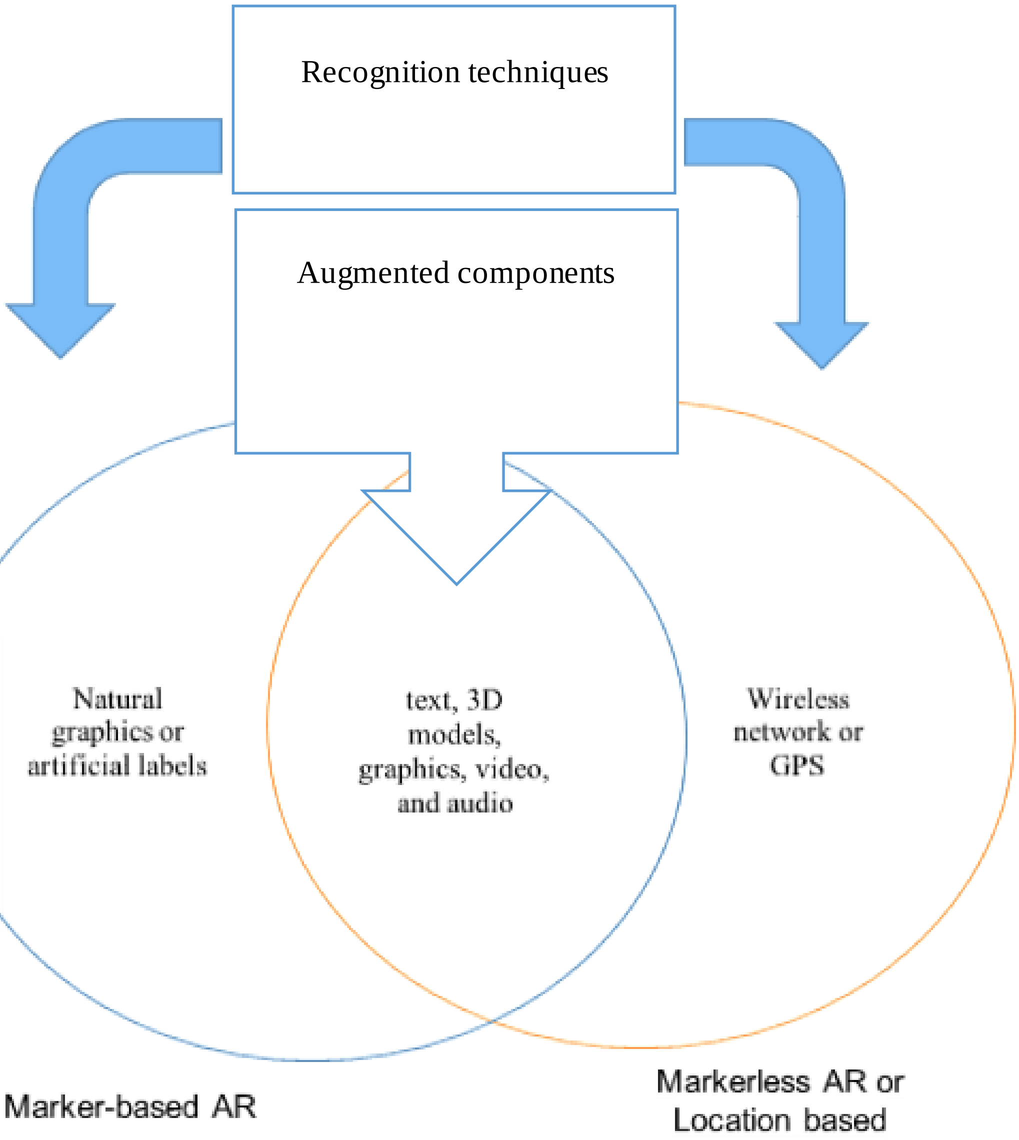


Figure 5: A comparison of Marker-based AR and Markerless AR adapted from (Cheng & Tsai 2013, p. 453) (Prepared by author)

1.4 History of Augmented Reality

In 1965, Ivan Sutherland announced in his paper "The Ultimate Display", a program developed in computer graphics with his students. In this program, the environment was created entirely with perfect realism. Sutherland notes that once someone looks at the display screen, they will be immersed in it, interact with objects, change it, hear and feel all objects in their surrounding environment (Sutherland, 1965). Figure 6 shows the first AR prototypes.

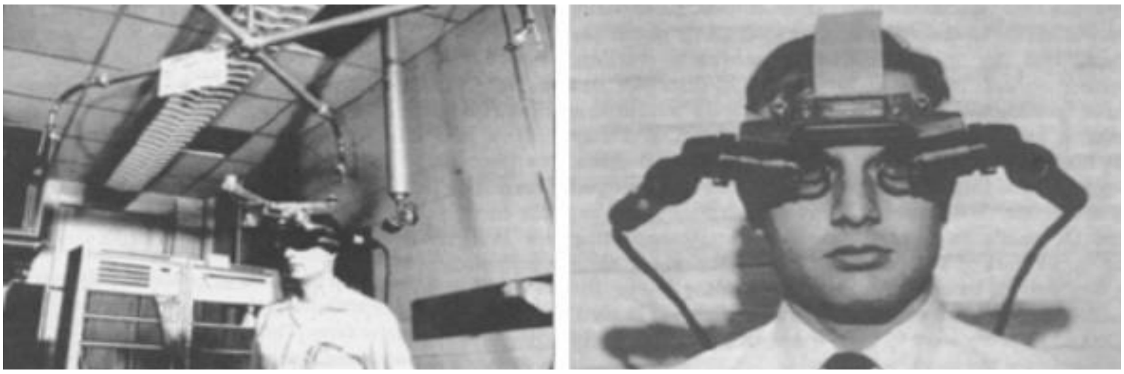


Figure 6: The world’s first head-mounted display with the “Sword of Damocles” (Sutherland, 1968, p. 759)

In 1975, the Videoplace technology was created by Myron Krueger. This technology was installed in a room, and users interact with virtual objects for the first time (Krueger et al., 1985). By engaging users in a digital environment, VR simplified the interaction between humans and computers. Virtual Fixture is an example AR system that was developed in the early 1990s by Louis Rosenberg at the USAF Armstrong Laboratories. It was the first fully immersive AR used to improve human performance (Rosenberg, 1992). The term “augmented reality” was formulated by Caudell and Mizell (1992), scientists at Boeing Corporation, to represent the system that can help familiarise pilots with the electronic cables in the aircraft (Caudell & Mizell, 1992). The aim was to help workers at an aircraft factory with the display of wire bundle assembly schemes in a Head-Mounted Device (HMD) view. HMD is a device worn over the head. Features a screen to display data in front of one or both of your eyes.

The physical size of computers has been reduced gradually, and that paved the way for wearable computers (Starner et al., 1997). Computers such as the Apple Newton MessagePad (1993), the Palm Pilot (1996), and palmtop computers the Psion I (1984) have been introduced with small size and are mobile. Many mobile computers, like tablet PCs, personal digital assistants and mobile phones, are now available and that will facilitate the use of AR. In 1993, the GPS-based outdoor AR system was developed by Loomis et al. (1993) to assist visually impaired people in navigating their environment with spatial audio overlays. Soon mobile devices that had tracking services become familiar with a small size to support a graphic overlay in mobile locations.

The prototype of a mobile AR was created by Feiner et al. (1997) that creates the overlaid 3D graphics of AR to provide information about buildings and artefacts. By the late 1990s, AR had become a much-discussed research topic. Conferences are held on AR every year, such as the International Symposium on Mixed Reality, the Designing Augmented Reality Environments workshop and International Workshop and Symposium on Augmented Reality. Besides, funded organisations created the Mixed Reality Systems Laboratory3 (MRLab) in Japan and the Arvika consortium4 in Germany.

Also, The ARToolKit was released by the Nara Institute of Science and Technology's Hirokazu Kato into open source community allowing users to capture a video of the real world augmented with 3D graphics and virtual objects on mainstream operating systems for the first time in simple handheld devices (Kato et al., 2000). The first use of AR applications began to appear in 2008. At the same time, several surveys were conducted by (Azuma, 1997; Azuma et al., 2001) illustrating an outline of AR advances, defining its issues, and summarising developments. Figure 7 demonstrates the history of AR development from 1950 until 2008 regarding AR concept development. A significant advancement in the AR technology happened from 2008 till now are discussed in the paragraph below the figure.

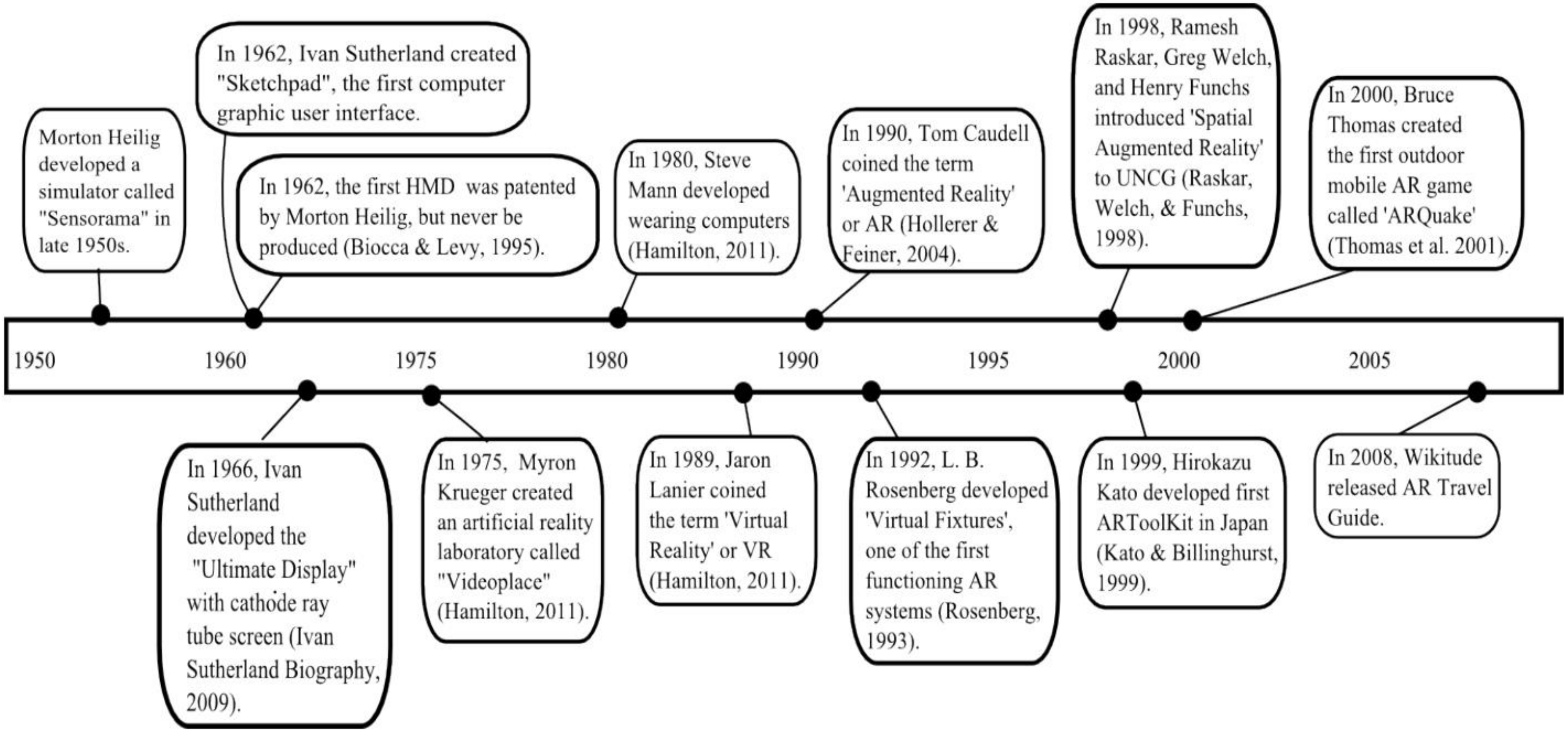


Figure 7. History of AR development (Yuen et al., 2011, p. 122)

Today, AR is applied in various contexts, including public safety, healthcare, education, gas and oil, and tourism and marketing. AR products have been introduced to the market and have been implemented on various phone headsets such as Google Glass, Oculus Rift, Meta 2 headset, Microsoft HoloLens, CastAR, and heads-up displays in car windshields (Uma, 2019). Nowadays, using small mobile devices like smartphones or tablets, empower the augmentation of data in different forms (text, images, video, sound, and more), sitting on top of the real world. An AR project called Bridge was developed by Google, which is a new headset that mixes the real world with virtual objects and enables iPhone users to enjoy the unique experience (Davies, 2017). Many are expecting great things from Apple regarding AR. According to the latest reports, the iPhone will have a smart connection that will work with an AR headset. According to Phelan (2017, p. 15), Tim Cook, Apple CEO, commented on the future of AR "I regard [augmented reality] as a big idea like the smartphone. The smartphone is for everyone; we do not have to think the iPhone is about a certain demographic, or country or vertical market: it is for everyone. I think AR is that big, it is huge. I get excited because of the things that could be done that could improve a lot of lives."

1.5 Creating Augmented Reality

AR is capable of adapting to changing the place and time of learning, introducing new and additional methods and choices. Educators understand that imagination and communication are vital to the learning process. There are two options for educators to create an AR experience (Peddie, 2017): **browser and application:**

- **Browser:** this type uses traditional web technologies such as HTML, XML and HTML5 to express the content and present some of the tracking technologies such as location-based services, ID market detection, QR-codes, barcodes, and advanced 2D and 3D tracking.

A camera, GPS, and compass is necessary to retrieve the information from the online resource when the user is at the exact geographical coordinates, and then the objects and information are superimposed into the real view (Furht, 2011).

There are three free web browser services for creating AR location-based content:

Aurasma (www.aurasma.com)

Aurasma is now the visual browsing platform of Hewlett Packard's AR. The Aurasma image recognition technology usually uses smartphones or tablets to define printed pictures and then overlays digital media in the form of 3D and 2D animations and models, web pages, and videos onto the users view.

Layar (www.layar.com)

Layer is another AR company, founded in the Netherlands in 2009. Users may generate AR contents with the web-based Layar Creators with various easy to use drag-and-drop characteristics.

Wikitude (www.wikitude.com)

Wikitude Studio is an AR web-based content creation tool designed for producing AR projects by users and publishing them in minutes on the Wikitude App without computer programming abilities.

These AR building applications are free and available to be downloaded. Applications for Aurasma, Layar, and Wikitude are compatible for: • Apple iOS • Google Android Windows Phone Symbi.

- **Application:**

Nowadays, a variety of AR applications are designed to be used in mobile devices. These applications have several features that allow the user to create AR contents for different uses and provide interactive experiences to the target audience (Peddie, 2017). These applications are compatible with mobile technology such as smartphones or tablets and available to the user even in a different operating system (e.g. Windows, phone Android, iOS). In education, printed materials can be turned into more interactive experiences by AR applications to engage, motivate, and encourage learners (Furht, 2011).

1.6 Augmented Reality System Architecture

Figure 8 below presents the process of AR technology. Mainly, the AR system is about capturing the real world, analysing it, comparing it with conditions identified by the designer, and displaying the results to the end-user (Montero et al., 2019).

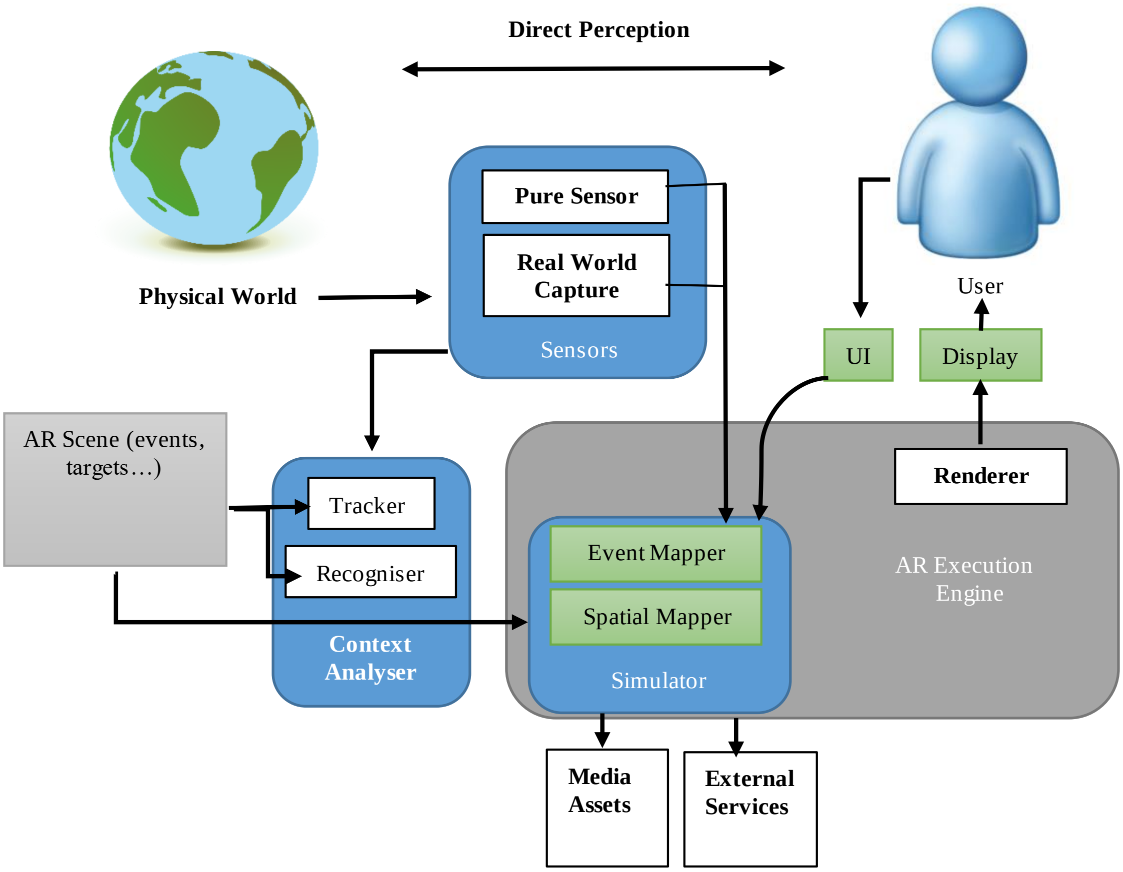


Figure 8: AR-system-architecture adopted from (https://www.coursera.org) (Prepared by author)

AR technology usually functions by using different types of sensors, such as (microphones, cameras, compasses, and accelerometers) to connect with the physical world. Then, data that comes from the sensors will be analysed by a Context Analyser. After examining the data, the results will be transferred to the Execution Engine to confirm if the conditions like the GPS position of the end-user, which are designed by the AR makers, are met. The Execution Engine produces the results to the end-user in different displays such as speakers, vibration devices, and screens. The User Interface components can be used to allow users to interact with the system. Finally, the execution engine will connect with other servers to distribute media assets like 3D objects and augment these objects with the sense captured by the camera (Han et al., 2019; Kirner et al., 2012).

1.7 Augmented Reality Displays

AR displays can be categorised into three types based on their position between the viewer and the real environment: head-worn displays (HWD), handheld displays, and projection displays (Peddie, 2017). Bimber and Raskar (2005) demonstrated in Figure 9 the different options of placing an image that can be formed to support AR systems, where the displays should be located with consideration to the real object and observer, and what kind of image is produced (i.e., curved or planar).

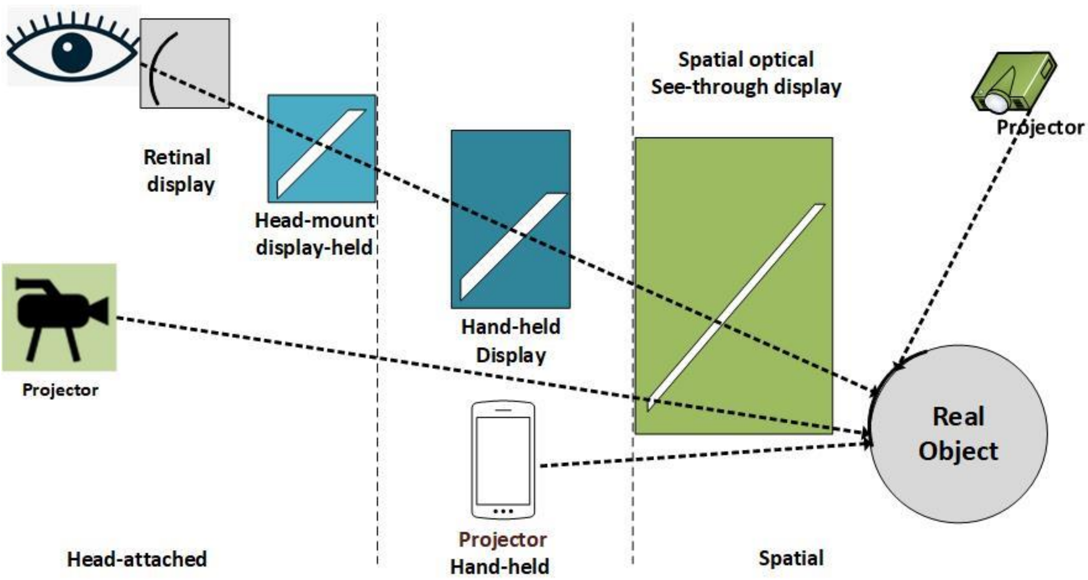


Figure 9: Positioning and visual display techniques adopted from (Bimber & Raskar, 2005, p. 2) (Prepared by author)

1.7.1 Head-Worn Displays

This type of display is worn on the head, allowing images to be displayed in front of users' eyes. Azuma et al. (2001) and Peddie (2017) classify HWD into two types: **video see-through and optical see-through:**

- **Video see-through** uses a video camera mounted on the headgear to capture video as a background and overlay 3D computer-generated objects on that real video on an opaque display. In other words, digital content is overlaid on a video view of the real world (Peddie, 2017). A video seen- through HMDs has the advantage of consistency between synthetic views and real, and comprise a variety of image processing techniques (please see Figure 10).

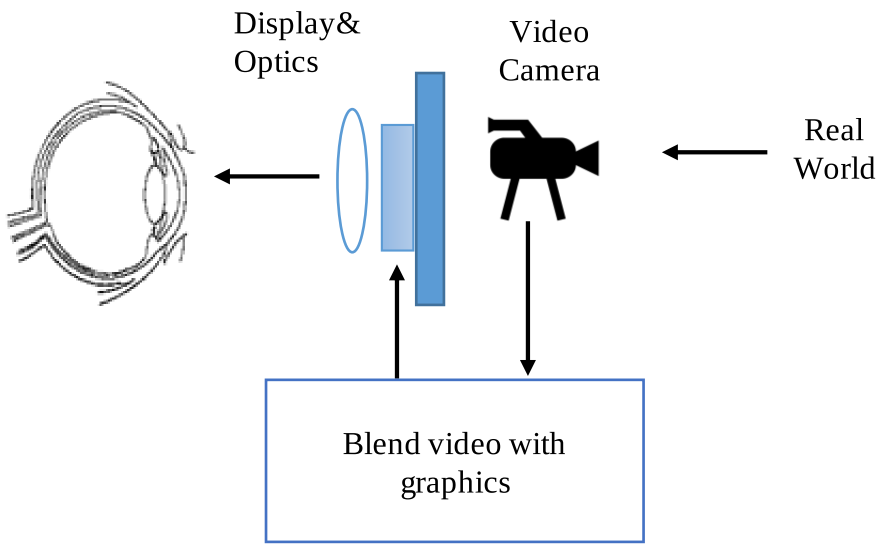


Figure 10: Video see-through concepts adopted from (Danciu et al., 2011, p. 14) (Prepared by author)

- **Optical See-Through:** Uses a holographic optical element to overlay 3D computer-generated objects and allow users to see the real environment with their natural eyes. So, the real environment is seen via semi-transparent mirrors located in front of the user's eyes, as shown in Figure 11. Thus, the real and virtual world view will be combined through these mirrors by reflecting the computer-generated images into the user's eyes (Danciu et al., 2011).

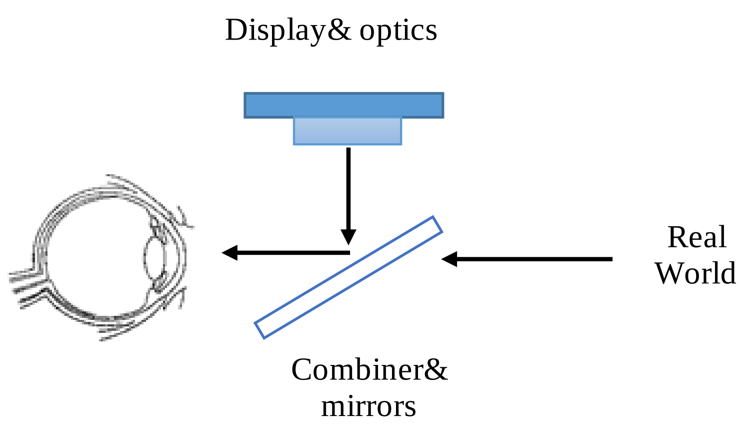


Figure 11: Simplified optical see-through adopted from (Danciu et al., 2011, p. 14) (Prepared by author)

Several companies such as Google have designed head-worn AR display with small size embedding the display optic within eyeglasses. The MicroOptical family manufactured eyeglass displays via embedding two right-angle prisms in a regular prescription eyeglass lens (Azuma et al., 2001). The image is reflected in a small colour display, mounted facing forward on an eyeglass framework.

1.7.2 Handheld Displays

Handheld displays are flat-panel Liquid-Crystal Displays that some AR systems use by connecting a camera to run video see-through-based augmentations. The handheld display is used as a magnifying glass or a window that shows real objects with an AR overlay. Zhou et al. (2008, p. 198) suggested that “Handheld displays are a good alternative to HMD and Head-mounted projection display (HMPD) systems for AR applications, particularly because they are minimally intrusive, socially acceptable, readily available and highly mobile”. Nowadays, handheld devices such as Tablet Panel Computer (PCs) and phones (cell phones, smartphones and PDAs), are everywhere and can be used for a mobile AR platform (Peddie, 2017).

1.7.3 Spatial AR (Projection displays)

In this approach, the projector is used to direct chosen virtual information on the real objects to be augmented. The aim of the technique is displaying graphical information directly on a real object or designed work surface with no need for unique eyewear (Zhou et al., 2008). According to Peddie (2017), this technique is an excellent choice for applications which do not require users to wear anything and to provide minimal intrusiveness. This technique allows collaboration between users, with applications in museums, universities, laboratories, and in the arts community (please see Figure 12).

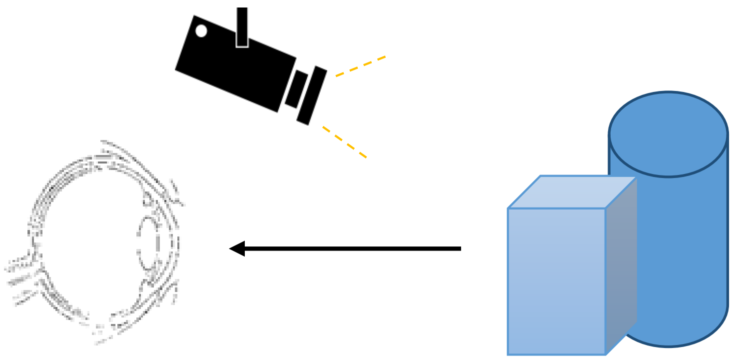


Figure 12: Projection displays concepts (Bennett & Stevens, 2005, p. 4) (Prepared by author)

In the previous sections, AR technology was defined, its implementation history was explained, and the existing types were explored that could be integrated into higher education. The research setting, purpose, objective, questions, significance, and the research approach are discussed in the next sections.

1.8 Research Setting

This research focuses on the SAn context, and the following parts will be a presentation of its profile. A brief description of Saudi demographics, Saudi society, Islam, economy, and education system will be discussed. These characteristics will impact on the development of innovative learning methods and the education system.

1.8.1 Saudi Arabia Setting

SA was established in 1932 by ABD AL-AZIZ bin Abd al-Rahman Al Saud (Ibn Saud). SA region is located between the Red Sea to the west and the Arabian Gulf to the east. It is also situated in the south-west corner of Asia at the crossroads of Africa and Europe. SA is bounded on the north by Kuwait, Jordan, and Iraq; on the south by the Republic of Yemen; on the east Qatar and the Arabian Gulf; on the south-east by the United Arab Emirates and Oman; and on the west by the Red Sea and the Gulf of Aqaba. The official religion of SA is Islam, and most of the Saudi society is Muslim (Al-Saggaf & Williamson, 2004; Alebaikan, 2010; Oyaid, 2009). The two holy mosques of Medina and Makkah are important Islamic sites which are situated in SA, and that makes SA an important country in the Muslim world. Al-Saggaf (2004, p. 1) added that “Islam plays a central role in defining the culture, and acts as a major force in determining the social norms, patterns, traditions, obligations, privileges and practices of society”.

Saudi society follows Islamic instruction as a completed system in all areas of social, business, and personal practices (AlMunajjed, 1997). The interaction between men and women who are unmarried or not related is prohibited for religious reason in SA, and they need to be segregated. The segregation rules are applied in business, education, public transport, job opportunities and, social situations such as shopping and restaurants (al-Rasheed, 2010; Almunajjed, 2010). According to Al-Saggaf (2004), applying these rules influences public and social life in SA, including education. Gender segregation is supported in SA because of its religious and cultural constraints (Onsman, 2011).

SA (please see Figure 13) occupies 2,150,000 km^2 approximately 80 per cent of the Arabian Peninsula. The capital city of SA is Riyadh, which is the largest city. Based on the latest census in 2020, the total population is 34,218,169 (General Authority for Statistics, 2020). The discovery of oil in the 1970s has led to significant industrialisation and urbanisation in SA. SA is taking its place in the global economy through its massive oil reserves. The economy of the Kingdom relies on oil prices, which has brought the SA budget to a surplus after almost a decade of budget deficits (Ramady, 2010). In April 2016, the government of the SA launched a strategic vision known as the "Saudi Vision 2030" to reduce oil dependencies and improve public sectors, including education, health and tourism, in performance and spending efficiency (Saudi Vision 2030, 2016).

Figure 13: Map of Saudi Arabia Source: David Vallejo, n.d.

1.8.2 Saudi Education System

The educational system in SA was shaped by Islamic philosophy and tradition. Three objectives underpinned the establishment of the educational system: (a) all citizens must be provided with at least a primary education; (b) following economic and technological changes, students must be provided with relevant, necessary skills; and (c) students must be educated in the practice and values of the Islamic culture (Aldawood, 2000). In 1975, the Ministry of Higher Education was established. There were only eight public universities in 2003, which served a large population of 22 million people. Gradually, the Kingdom started working to enlarge and reform higher education by directing a larger portion of its budget towards higher education. The budget for higher education has increased since 2004, to $15 billion, much of which has been spent on establishing more than 100 new universities and colleges. According to Ramady (2010), there has been an impressive transformation in SA education in a short period. In the period 1927 to 1960, only seven Saudi PhD students graduated from international universities; while in 2001–2002 alone, 185 PhD students graduated, including 22 women. The education sector is one of the main pillars of SA's 2030 Vision. A little more than a year ago, the Education Department introduced the "Future Gate" initiative to promote digital learning and to "change the entire context" of schools to emphasise the importance of digital transformation (Saudi Vision 2030, 2016)

Education is segregated by gender, so boys are educated in separate locations to girls, and have male staff members; and girls' schools are staffed by women (Smith & Abouammoh, 2013). With the new changes in SA, some private universities and schools are moving away from segregation. For instance, King Abdullah University of Science and Technology, which was founded in 2009, is the first mixed-gender university campus in SA (Laessing & Alsharif, 2009). Also, one of the Vision objectives is to measure citizens' satisfaction by Quality of Life 2020. For example, education is one of the factors used to measure the satisfaction of the citizens. The quality of life in education is measured through reliable facilities, technology and high-quality education systems. Moreover, improving the overall number of SAn universities ranked worldwide is a crucial dimension that affects the quality of life program objectives (Saudi Vision 2030, 2016). Universities must ensure that their teaching methods are developed, and technology is an integral part of their educational goals, to be internationally recognised and classified

Teaching and learning procedures in the higher education system in SA currently fail to enhance students' motivation and engagement, inspire critical thinking, or promote self-learning (Hamdan, 2014). According to Alnassar and Dow (2013), learning and teaching in SA's higher education sector have several challenges. The current curriculum does not appropriately support students' critical thinking; development and improvement of teaching methods are not encouraged; there is a lack of adequate training and workshops for faculty members and teachers; self-learning is not encouraged, and problem-solving skills are not explicitly taught. Smith and Abouammoh (2013, p. 6) stated that "SA has received sustained international criticism over many years about the quality of its education system, with major concern directed at the content of its curriculum and the didactic nature of its pedagogy". Moreover, students in higher education lack motivation and the teaching methods are not improving this situation (Alamri, 2011).

Saudi universities are trying to combat these challenges by developing a contemporary curriculum and provide more advanced technological teaching facilities (Smith, 2013). This challenge involves the ability of students to understand the effective online delivery of information and advanced technological teaching facilities (Smith & Abouammoh, 2013).

1.9 The Need for an AR Framework in Saudi Universities

Saudi universities are aware of the vital role of modern technologies and their impact on the students' learning outcomes. However, small steps are being taken towards integrating advanced technologies in the SAn higher education system that could be related to a lack of frameworks and guidelines that support the successful and effective technology integration (Alebaikan & Troudi, 2010; Al-Zahrani, 2015; Narayanasamy & Mohamed, 2013). This is supported by the literature, which indicates that conceptual frameworks regarding the implementation of technologies such as AR systems are crucial (Ertmer et al., 2012; Rasimah et al., 2011). Many studies focus on the effectiveness of AR on students' learning outcomes (Bower et al., 2014; Lu & Liu, 2015; Lin, Chen & Chang, 2015). Nevertheless, there is an evident lack of a comprehensive standard set of AR incorporation factors in higher education, which could contribute to the slow adoption of AR in SAn universities.

Furthermore, a comprehensive AR model or framework, particularly in the developing countries, is not empirically validated or tested. SAn universities remain at the pre-adoption level with little or no guidance to integrate AR applications into their teaching and learning. An appropriate AR framework is, therefore, essential to guide them in their need to align with their strategies of technology integration. Thus, this research aims to develop, understand, and evaluate an AR environment and framework for universities in SA. The AR approach in education was examined and assessed in SA's higher education sector, and the development of a new AR framework was sought. For these reasons, it has been found that SA is an excellent candidate for this research: the adoption and implementation of innovative technologies like AR in the educational sector in SA. The perceptions and attitudes towards these technologies are predominantly positive, and SA, as a wealthy country, has access to a large budget and domestic engagement to improve the education system through the inclusion of sophisticated technologies (Mousa & Ghulam, 2019).

A valuable part of the success of technology implementation in the education system is the 2030 Vision of the Saudi Government (Saudi Vision 2030, 2016). Thus, the present research outcomes align with the Vision and may be helpful for university administrators, decision-makers, e-learning departments, and ICT departments in identifying the required factors to encourage and boost the uses of AR by professors and students in SAn Universities. Another beneficial driver of adoption of AR in education is the youthfulness of the Saudi population (Sallam, 2013). 37% of the population in SA is under 14 years of age, and 51% is under 25 years of age (General Authority for Statistics, 2020).

Finally, because the literature on the use of AR technology and its associated applications in universities has just emerged, there is a lack of research and information about this subject as it applies in SA, specifically, and in the countries of the Gulf Cooperation Council (GCC), and the Middle East, generally. The final AR framework developed in this research provides an overview of driving factors for AR adoption in the Saudi higher education system and provide a set of recommendations to Saudi universities to improve the implementation of AR technologies.

1.10 Research Objectives and Questions

The specific objective of this research, as will be elaborated on in section 3.2, is to conceptualise AR learning environments for Saudi universities by providing a framework with driving factors for effective implementation and provide the stakeholders of Saudi universities with actionable recommendations to make a successful implementation of AR learning environment in Saudi universities. The factors for AR integration in higher education in Saudi universities will be identified, and an AR framework will be developed for these universities. Key stakeholders such as students, academic staff, e-learning administrators, AR developers, and experts in education technology from Saudi universities were invited to participate in the research to evaluate the factors that contribute to AR integration in universities in SA. The outcome of this research is an AR framework, and this work will benefit the stakeholders listed. This thesis aims to create an environment conducive to the effective implementation of AR technologies.

This research set out to determine the contextual, individual, university and technology-related factors (e.g.., perception, willingness, culture, pedagogy, support, and usability) that will have the most influence on AR adoption. To obtain further information about this, please see Chapter 3. Another purpose of this multi-faceted approach is to develop a holistic framework that includes all factors related to the adoption of AR in higher education and provide several recommendations and suggestions for successful incorporation of AR applications based on previous studies as well as this study's results, particularly for universities in SA. To achieve this, the following research objectives were established:

1. To ascertain the factors that must be included in the AR framework for high education in SA.
2. To determine students', faculty members', and e-learning departments' perceptions towards AR as a teaching and learning tool compared with the traditional methods.
3. To assess AR experts' perceptions towards the resulting augmented reality framework.

To fulfil the objectives of this research, the following questions were addressed, as discussed below in section 3.2, to provide insight critical for developing a holistic AR framework and for the successful integration of the AR environment in SAn universities:

Q1 What are the factors that must be included in the AR framework for higher education in Saudi Arabia?

Q2 What are the perceptions of students, faculty members, and e-learning departments towards integrating AR as a teaching and learning tool compared with the traditional methods?

Q3 What are the AR experts' perceptions towards the augmented reality framework?

1.11 Theoretical Significance

From a theoretical point of view, the current research was necessary because it would increase the current understanding of how AR is increasingly used in the education system and can be used profitably in higher education for educational purposes in developing nations, which remains highly unexplored. The future significance of this finding is based on using the first stage of Rogers' 'diffusion of innovations' theory as a conceptual signpost, on offering an indicator, quantitative and qualitative, of how ready the SAn universities are to adopt AR in future. In light of this research, the lack of theoretical frameworks to guide the adoption of AR in higher education is of concern. Furthermore, this research aims to addresses the lack of empirically validated frameworks with no or limited data evidence from participants. Therefore, this research aims to add to theoretical and academic knowledge about the essential factors needed to guide successful implementation of AR in teaching and learning approaches in universities.

The context of SAn higher education represents a set of ambiguities and requirements that entail careful examination before the introduction of widespread AR in university pedagogy. By bonding approaches drawn from extant literature on implementation of AR in universities globally, this research suggests a framework of factors which might reinforce integrated and well-considered incorporation of AR in higher education in SA. The research findings will benefit stakeholders including academics, researchers, PhD and master's degree students in SA universities who would benefit from the support of AR technology in their teaching, learning and activities as well as in other developing countries.

1.12 Practical Significance

In practice, the purpose of the thesis is to understand the potential factors that may support the successful integration of AR into SA's higher education system. This research provides practical guidance to allow tertiary institutions and the government to make better use of the many advantages that AR can bring to achieve excellence in digital learning. The research outcomes will provide a framework that can be utilised by academics, decision-makers, and universities as a blueprint to adopt AR technology in learning processes. Until recently, to the best of the researcher's knowledge, no research has been conducted on the integration of AR in Saudi universities.

Furthermore, the outcomes of this research align well with the 2030 Vision as it would be providing a helping hand to the government and education sector assisting them to introduce new technologies as learning tools and provide a means for the development of the higher education sector. The research aims to enrich the field of higher education in SA, e-learning field, and the field of educational technology by incorporating practical and interactive tools such as AR technology. Besides, this framework can be introduced in the GCC countries as they share many common factors such as culture, religion, social, languages, and economic and financial system.

1.13 Overview of the Research Approach

The present research employs a mixed-method research design (Explanatory Sequential Design), in which the data will be collected through both quantitative (online survey) and qualitative methods (SSI interviews), analysed individually, and then discussed together (Ivankova, Creswell & Stick, 2006; Johnson, Onwuegbuzie & Turner, 2007). The present research was based on mixed, sequential and explanatory research methods, which enabled a better knowledge of the outcomes of the quantitative strand of the research.

The quantitative approach, conducted first, aimed to understand students', faculty members', and e-learning department staff's awareness and opinions of the AR method, and to develop a set of new factors from the survey (Venkatesh et al., 2013). Survey data was used to construct the factors of AR integration in higher education. In the next phase, AR experts and educational technology staff were interviewed to explore the quantitative results from the survey in more depth to gain more insights, reasons, deeper understanding, and explanation of these constructed factors in the framework. The study population in the first phase comprised students, faculty members, e-learning department staff, ICT staff, and experts in educational technology from universities of SA.

Quantitative data (online survey via Qualtrics Survey Software) was used to measure the perceptions and contextual, individual, university, and technology-related factors to identify perceptions and the factors for the proposed framework. The survey aimed to pinpoint factors from the perspectives of participants concerning the use of AR. The survey was conducted to explore and assess the perceptions of stakeholders towards AR as a learning method and AR incorporating factors. Multivariate statistics using the Statistical Package for the Social Sciences (SPSS® version 25) software was used to run preliminary analysis and the Exploratory Factor Analysis (EFA) to identify a set of common factors that linearly explain the correlation between the original variables and reflect a consistent interpretation of the survey data, unlike the original groupings. The primary outcome of an EFA is a factor loading matrix. The EFA test results answered the question: What are the factors that must be included in the AR framework for higher education in Saudi Arabia? Moreover, preliminary analysis and EFA test results answered the question: What are the perceptions of students, teachers, and e-learning departments towards integrating AR as a teaching and learning tool compared with the traditional methods?

In the interview phase, the research used semi-structured, online interview not in real-time (asynchronous) with a selected number of educational AR experts to collect the data necessary to achieve the research objective and to support the data obtained from the online survey results. Researcher's notes and comments of participants were categorised and coded using (NVivo® 12) software. NVivo was used to import the transcripts and undergo thematic coding and analysis. Then Themes were organised into codes creating a comprehensive approach of crucial results. The qualitative phase was conducted for the following two rationales: first, it was conducted to confirm the answers to the first research question by the experts; second, was to answer the third research question of the thesis: What: from the educational AR experts' perspective, are the essential AR adoption factors? and to evaluate the AR framework resulting from the survey. The research flow is illustrated in Figure 14 underneath.

1.14 Overview of the Research Flow

As can be seen in Figure 14 below which is modelled by using a Unified Modeling Language (UML) activity diagram, the research was carried out in the following phases: a comprehensive review of the literature on the application of AR in higher education was conducted. A study gap was identified following a review of the literature, namely, the lack of current research by non-mainstream universities and higher education providers on the AR integration framework and system, in this case, SA.

The research questions and objectives for the research were subsequently formulated. The key themes and factors used to integrate AR in higher education in SA were identified using the content analysis of current literature, and these factors were then subsequently further tested through a quantitative data collection analysed by factor analysis and the qualitative data collection was analysed using NVivo 12. The next phase consisted of the improvement of the framework of the factors behind the successful integration of AR into SAn universities.

In order to confirm and evaluate the refined framework, educational technology and AR experts at universities and educational institutions in SA were interviewed. As a result of this final analysis process, a validated final framework was created with data evidence from participants of factors that underpin SAn universities ' successful AR incorporation.

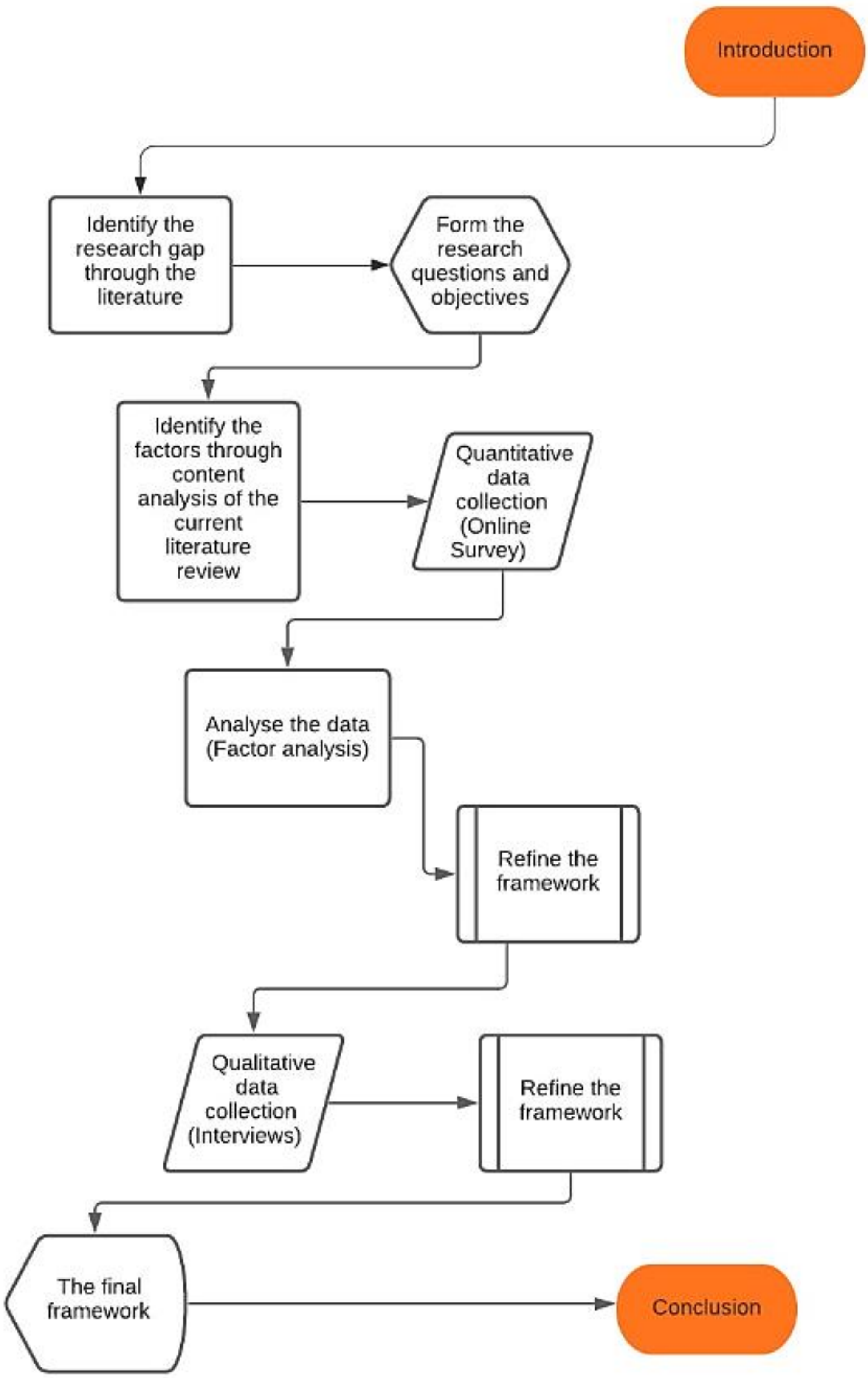


Figure 14: Research Flow (Prepared by author)

1.15 Thesis Outline

This section provides an overview of the thesis outline. The thesis includes six chapters:

- Chapter 1: (Current chapter) highlighted the background of the research, the aim of the research and the justification for this thesis. Also, it presented the focus of the research and questions and objectives of the research.
- Chapter 2: a comprehensive and critical review of extant literature related to AR studies, especially in education. The scope of the literature research was narrowed with selection criteria. This chapter provides a critical review of the educational implementation and use of AR factors in a higher educational context to develop the AR framework for SAn universities. Furthermore, several of the previous AR frameworks and models related to this research scope are defined to support the conceptual framework theoretically. Finally, the research gap will again be highlighted.
- Chapter 3: describes the research methodology and the research process. This includes justification for the research design for this research and a detailed explanation of the selected mixed-methods approach containing a quantitative survey followed by a qualitative interview phase. Methods used for data collection and analysis are also discussed at each stage.
- Chapter 4: discusses the survey process. The questionnaire items, survey management and analysis, are presented to refine the AR framework further and to make it available for assessment by stakeholders.
- Chapter 5: describes the final stage of the research, the examination of the qualitative results of the online interview to improve the framework after assessment by the experts.
- Chapter 6: presents the findings and discusses the results in detail. This section also provides recommendations for the stakeholders for the implementation of AR in Saudi universities. It also concludes the thesis by summarising research contributions, discussing research limitations as well as providing recommendations for future work.

1.16 Conclusion

This chapter outlined the background to the research topic by presenting a definition of AR, its history and types. This chapter also introduced how AR technology has been one of the crucial fast-growing technologies especially in education and has been proposed as inclusion in instructional and learning approaches in universities owing to its capability for engendering interaction and promoting students' understanding and motivation.

This research has taken place in SA, which has been discussed in this chapter, including its geography, history, the socio-economic, and education system factors that affect the research context. SA culturally varies from mainstream nations in which most studies into AR technology have been carried out. Based on this, the chapter discussed the need for an AR framework for Saudi universities. The research questions, research objectives, research significance and research's possible theoretical and practical outcomes were also discussed. This section also provided an overview of the quantitative and qualitative methods utilised during this research, which will be discussed in chapter 3.

Chapter two will discuss AR literature in detail to find the gap and to develop a conceptual AR framework for universities in SA.

Chapter 2. Literature Review

2.1 Introduction

The previous chapter introduced the development of AR technology with the definition and its applications in the context of higher education. Furthermore, it explained the history of AR and explored its current types that could be implemented within the context of teaching and learning practices. The previous chapter also covered the SAn setting and education system. Chapter 1 formulated the research questions, and briefly outlined the research significance, design, strategy and the purpose of the intended study.

In this chapter, the literature is reviewed to explore AR, how it contributes to educational settings and its possible pedagogy impact. This chapter especially considers the approaches taken by universities when implementing AR to explore the common influential factors. This could mean the ideal situation for SA and any potential future adoption of AR into educational contexts. This chapter goes on to discuss the best practice AR use. It explores how AR is implemented in the fields of healthcare, marketing, architecture, design, technology, entertainment and, most notably, higher education. Following this, a review of academic sources provides an overview of AR's incorporation into higher education by reviewing various educational initiatives to incorporate AR technology for teaching and learning purposes.

A review of the extant AR research literature in higher education shows that researchers may have adopted the theoretical approach (Traxler & Kukulska-Hulme, 2005), with theoretical bases developed from other fields, such as other educational contexts, engineering, information systems and human-computer interactions. However, several calls in the literature have highlighted the need for a conceptual framework regarding the implementation of technologies such as AR systems (Ertmer et al., 2012; Rasimah et al., 2011). Therefore, a conceptual AR framework is developed using relevant mechanisms and relevant theories from literature. The pertinent factors of integrating AR in the higher education system from the literature have been grouped to represent the one conceptual framework for implementing AR into the higher education system in SA. This chapter thus sets out the basis for the research questions and covers the factors that could best support the effective adoption of AR in universities in SA.

This chapter is structured in the following format: Section 2.2 discusses the scope of the literature review. In Section 2.3, the background on the use of AR in different sectors, including higher education, is discussed. It also provides an overview of the extant research into AR as a pedagogical tool in the higher education setting. This is followed by Section 2.4 and Section 2.5, which examine studies in developed and developing nations in terms of AR technology incorporation and provides a summary of the most considered factors.

The challenges facing the use of AR in universities are discussed in section 2.6. Sections 2.7 presents a detailed account of AR models and frameworks from the extant literature, followed by individual technology adoption theories in Section 2.8. In section 2.9, an integrated approach and the possible factors required for AR adoption are discussed. Section 2.10 discusses the gaps that this work aims at solving in the existing literature and provides an initial AR framework based on the literature review followed by the chapter conclusion.

2.2 The scope of the Literature Review

The effective way to start planning a literature review is to consider the extent to which the revision proposed fits in with Cooper's (1988) literature review taxonomy. Cooper points to the possibility of classifying literature reviews according to five characteristics: focus, goal, perspective, coverage, organisation, and audience. According to this taxonomy, this literature review research is classified as shown in Table 1.

Table 1: Literature reviews classifications according to Cooper's taxonomy.

Characteristic	Categories	Explanation
Focus of attention	Research outcomes	Focus on studies reporting on factors and outcomes of the adoption of AR in the education sector.
	Theories	Focus on AR Technology Adoption Theories, Models and Frameworks.
The goal of the synthesis	Integration Identification of central issues	Identifying the patterns and main themes for AR implementation in the educational environment, synthesising existing evidence and classifying potential factors for an initial framework.
Perspective on the literature	Neutral representation	Research results are interpreted as in the original studies.
Coverage of the literature	Exhaustive review	The current body of research on the subject has been comprehensively located and includes all studies that meet *a priori* eligibility criteria in the educational AR field.
Organisation of the perspective	Conceptual	Articles on the same priority area are collectively addressed.
Intended audience	General scholars such as academics, researchers, PhD and master's students in SAn universities who would acquire the supports of AR technology, Practitioners and policymakers.	Inform the various stakeholders about available information on AR integration factors in higher education as well as the current gap in research and practice.

To ascertain the factors that must be included for developing an AR framework for high education in SA, a literature review using Cooper's (1988) framework was used. Cooper's (1988) framework comprised the following steps: (1) problem formulation, (2) data collection, (3) data evaluation, (4) analysis and interpretation and (5) presentation of the results. This approach was used because it offered a systematic structure that improves the validity of the research synthesis.

Several scholarly databases were accessed for this literature review for informing the data collection stage. Science Direct, IEEE Xplore, ProQuest and SpringerLink were the most commonly used databases accessed. For a thorough search of appropriate materials for AR and education, unique keywords were entered. Keyword searches about AR included “Augmented reality and higher education”, “augmented reality use in education” and “universities and augmented reality” whereas key terms such as “AR”, “educational AR”, and “AR integration” also resulted in literature findings on the educational use of AR. The key terms "framework" and "model" were also included in the pre-defined search words to identify AR models and frameworks that have already been developed for educational purposes. The search returned 280 articles from the fields of Information Technology (IT) and educational technology, academic books, web articles, and journals, with a priority on literature published between 2001–2020. Section 3.3.5.1 discussed the methodology of conducting the literature review in more detail. Furthermore, this study reviewed the current AR literature, in general, and in SA, in particular, to explore which factors might influence and guide the adoption of AR in SA, and to develop an initial AR framework for Saudi higher education.

2.3 Background on the Use of AR

Since the 1990s, some sectors have extensively examined the use of AR systems, for example, in marketing, healthcare, architecture, entertainment, maintenance, tourism, and in education, more recently due to its capacity to include virtual items in real environments and bringing a different content forms (Azuma, 1997; Hincapié et al., 2011; Shin et al., 2010). Gradually, experience this technology became simple and portable with a versatile response to user input. Furthermore, AR technology decreased the difficulty level in doing a complex task such as surgery by providing cognitive support. According to Johnson et al. (2016, p. 40) “given the mounting interest and investment in VR and AR by technology companies, educational exposure to these technologies will benefit students in STEM disciplines or entrepreneurial pathways by preparing them for the future workplace”. This chapter will give a brief and general outline of the literature regarding the use of AR technology, and its current research in education, to identify gaps.

For further details of the AR definition, please see section 1.2. AR is applied in various sectors, and this section will discuss the AR use in healthcare, marketing, architecture, design, gaming, entertainment, and education because these can be seen as the best AR use cases.

2.3.1 AR in Healthcare

Healthcare is about protecting and improving the wellbeing of individuals and communities (Steinwachs & Hughes, 2008). To improve the quality of healthcare, innovative approaches have been sought, such as technologies that were developed and evaluated by researchers in the roles of healthcare professionals. AR is a new technology in healthcare educational practice and is revolutionising healthcare education. AR has shown a huge potential within the healthcare and nursing fields (Patrik & Bostjan, 2016; Wüller et al., 2019). Some AR applications can fill the gap between training for the skills required and the actual working environment, in a digital setting. AR needs constant strategic assessment in training healthcare curricula to be a winner in the digital revolution (Barsom et al., 2016). The Augmentarium developed innovative deployments for surgery training at the Maryland University which allowed doctors to use AR technology to see through the bodies of patients before starting surgery and conducting VR simulator surgeries refined their experience (Bethke, 2015; Meyer, 2015).

AR technology was introduced in healthcare in different studies as an assistance tool (Carlson & Gagnon, 2016; Patrik & Bostjan, 2016). In healthcare education, enhancing the clinical skills of trainee nurses is essential. A clinical skills lab can be overlaid with relevant resources, equipment and dummies by using AR to assist students in developing their abilities before undertaking clinical engagements and reducing anxiety and risks (Latif, 2012). Kotranza and Lok (2008) found that augmenting haptic feedback in the patient dummies showed the same actions as actual patients.
Moreover, doctors could use AR as a tool to aid in training and visualisation for surgery. Likewise, Azuma (1997) added that AR systems could be used by surgeons

to feel tumours through integrating vibration feedback tools or haptic devices with AR to identify the condition of the patient without requiring open surgery. Patrik and Bostjan (2016, p. 429) reported, "Assistive AR applications enable the user to see physical or other processes and information that are usually invisible or not easily accessible to the human eye in real healthcare environments".

AR is considered a well-known technology and is gaining more attention in medical education. Furthermore, AR can also power patient care via its ability to improve medical training and benefit both students and educators in medical education (Tasneem et al., 2019).

2.3.2 AR in Marketing

Companies around the world have started widely utilising AR for advertising and marketing (Rauschnabel et al., 2019). AR has the potential to reshape companies' methods of reaching out to their customers. The ability of more user interactive systems that AR provides, drives many companies to adopt this technology and to enhance marketing by allowing customers to virtually test and see the company's goods in the convenience of their home using their smartphone (Yussof et al., 2019). For instance, the BMW Company used AR technology to deliver the realistic feel of driving the BMW Z4 to interested parties. Customers can download the software and print the 3D symbol to see their own small BMW Z4 by holding the printed object in front of their webcam. This allows customers to drive the car using the keyboard and even change the colour of the car. According to Accenture (2019), this type of marketing increases the client's desire to purchase a BMW Z4.

In another example, Ray-Ban has adopted AR by developing a virtual webcam mirror application to allow a customer to try on selected sunglasses and move their head around to see how the sunglasses look from different angles. Moreover, customers can customise the colour and select their favourite optical frames.

IKEA, one of the leading furniture companies, has implemented AR technology in their marketing by developing a fantastic app that allows clients to design their houses virtually (Alves & Luís Reis, 2020). Customers can "see" the furniture, change the colour and even place the virtual product in their own home. This technology gives the customers a realistic idea of how to furnish their homes with IKEA products.

According to Huang (2017), AR makes the future of shopping exciting and more comfortable. Retailers can utilise AR to offer a more personal, interactive experience which will change the way of shopping forever.

2.3.3 AR in Architecture and Design

AR technology has been utilised in architecture and design to assist in visualising how objects and buildings will look before and after construction. AR systems are a useful tool that can guide construction workers while they are constructing an original building and allow them to develop their skills. Instead of wasting money and time in drawing and plans that might be misinterpreted in the actual project, AR helps to display virtual objects in the relocation/reconstruction and provide a definite plan to build quickly (Janusz, 2019). AR can be helpful in the workplace by augmenting the physical space with digital content which workers could interact within the actual environment where people work. In 2011, an AR method was used to help the community to engage in Christchurch's reconstruction after the destructive 2011 earthquakes. Tadros (2011) created an AR application that enabled users to picture destroyed buildings and the proposed substitutes.

The ARTHUR project is a sample of implementing the AR system for designing urban planning. AR displays and optical see-through were tools used to support architecture design (Broll et al., 2004). AR technology was used in that project to enhance real collaboration between planning decisions and a sophisticated design instead of using paper-based sketches.

Smart Vidente is another application of mobile AR in Architecture that was developed by Schall et al. (2013). AR is used to visualise underground infrastructure designs and maintenance to offer mobile workforces' abilities for on-site planning and inspection. Most of these applications/studies' results indicated that AR technology is set to enhance the current practices of building processes, design process, and architectural visualisation.

2.3.4 AR in Gaming and Entertainment

Currently, digital entertainment is an essential part of daily life for the new generation and has become more critical in supporting economic growth. In the meantime, new technologies have been used to provide a particular digital entertainment experience to gain the support of the market and the public. One of these technologies is AR, which introduces a new way of interaction and attains rapid growth in entertainment.

The gaming and entertainment field shows a growing trend towards using AR (Ashfaq & Sirshar, 2018). AR technology enhances the way of playing by allowing users to control most objects tangibly. AR allows players to capture fantastical creatures, fight with aliens or zombies while walking, and bring Ghostbusters to life in the real-world environment. Mangur (2020) stated that these games do not demand expensive headsets; they just require an AR-enabled smartphone.

One of the best-known examples of using AR in gaming is Niantic's Pokémon GO application. This game has gained rapid popularity and enabled players to go out, walk around and catch virtual Pokémon in the real world. Portales et al. (2010) designed an AR-immersive cinema at the visitors' centre of the Aula Natura to immerse users into history that combined past and present. Users were transformed into fictional characters by merging the AR application with projected filming. The user was required to carry or wear AR markers which were integrated with objects such as hairbands. Two projectors were used, one to project the film and the other the augmented user interface. Both pictures were projected spatially on a wall as a projection screen. The combination of both projections serves as a chroma key to incorporate the user's image in the video sketches.

2.3.5 AR Implementation in Education

Educators and teachers are seeking modern teaching tools, technologies, and methods to improve learning, promote self-learning, and to involve students in their learning actively. AR is a tool with an exciting group of new technologies that has the possibility to enhance learning outcomes. The learning environment is facilitated by AR technology through merging students' reality and digital resources into a physical environment (Cabero Almenara & Barroso-Osuna, 2016; Chen & Wang, 2015; Sommerauer & Müller, 2014). Sharples (2005, p. 147) describes the integration of technologies into practice in learning as "every era of technology has, to some extent, formed education in its own image. That is not to argue for the technological determinism of education, but rather that there is a mutually productive convergence between main technological influences on culture and the contemporary educational theories and practices."

People can be trained and educated by using many different methods to increase their knowledge and develop their skills. These methods include attending classes and lectures with textbooks, handheld devices, computers, and so on. A person's surrounding, such as the access of individuals to various technologies, influences the choices of learning innovation (Lee, 2012). In traditional learning approaches, the students are treated as an object in the teaching process. For instance, students attend class to only receive the information and knowledge without any practical and active role (Rose & Meyer, 2006). Despite the paper or digital textbooks that were found to be the core source of learning materials (Fan et al., 2013; Hilton, 2016), research indicates that students taught with multimedia lectures were better prepared for the lesson than students taught with only textbooks (De Grazia et al., 2012). Enhancing lectures and classes with multimedia interactivity such as visualisations, digital simulation, and animations are essential for improving students learning outcomes.

However, learning styles are diverse among students. According to Hsu (2017), students' learning performance will not be the same, even when students are receiving the same treatment. There is a reason that students prefer different learning styles and methods. Rose and Meyer (2006) revealed a model called the Universal Design for Learning (UDL) which is considered an essential reference model for policymakers, researchers, administrators, and teachers to guide educational practices and eliminate barriers in curricula, educational methods, and teaching materials. The principles of the UDL guides the educational technology adoption in learning in order to develop the students' brain activity (Rose & Meyer, 2006), and these principles include:

- The information needs to be represented in multiple means and on different media.

- Students should be provided with multiple means of action and expression to exemplify what they know.
- Teachers/instructors should promote various means of engagement to motivate students to learn and provoke their interest.

According to Wu et al. (2013), educational AR technology use is acknowledged as the bright future of education. In 2012, the Horizon report was released by the New Media Consortium, stating that AR technology is the latest technology for teaching and learning (New Media Consortium, 2012). The properties of AR technology, such as interacting with virtual objects in the real environment, increase students' motivation and attention, assuring learning by doing and learning by experience, attracted attention (Barrow et al., 2019). Using AR in education can complement a regular curriculum through integrating audio, video or text and graphics into a student's surroundings or textbook in a real environment. AR enables the student to experience other learning styles by merging educational reading material such as textbooks with additional and supplemental information and media (Gopalan et al., 2016). In an early example, textbook pages were attached with markers that, when scanned by AR, displayed multimedia and 3D graphs to the student (Duh & Klopfer, 2013). AR is increasingly becoming a practical instrument of instruction rather than being a technological novelty.

In the following sections, learning styles and pedagogical theories, that AR can fit and support in education, will be discussed in detail. Different AR applications and models in education are reviewed, and some factors that have been identified related to adopting AR in an educational setting are discussed.

2.3.5.1 AR Applications in Education

Designing AR learning environments have led researchers to create a variety of instructional and learning approaches and applications. AR has been recognised as a useful tool for supporting the understanding of students in various scientific industries, such as environmental science (Hsiao et al., 2012). AR, as an educational method, can support students at a personal level, developing both motivation and engagement (Klopfer & Squire, 2007; Luckin & Fraser, 2011). According to Luckin and Fraser (2011), using AR in a static environment can support different learning activities such as problem-solving. Alien Contact! an AR-based simulation was designed by Dunleavy, Dede and Mitchell (2009) to teach different skills such as mathematics and art to US students in middle and high schools. The results indicated that Alien Contact! Increased students learning motivation, enhanced cooperation among students and increased their understanding.

Furthermore, an AR educational application for the study of biology was developed by Juan et al. (2008) to enable the students to learn about the interior of the human body. After examining their AR application with Spanish children, the results were positive. Learning using the AR system increased enjoyment, and it was a useful tool for young students not only to learn the inner part of the human body but also to learn other materials.

A Hedley (2003) conducted a study to compare college students learning geography under computer-based conditions versus AR. According to their results, students in the computer-based group created less detailed mental representations than the AR group. Another possibility of integrating AR applications as a learning method is in the traditional learning of history. In traditional learning methods, students use books, photos, and historical documentaries. While with AR, students can learn and interact with historical information in an exciting way at one place in real space and time (Kysela & Štorková, 2015). This style of learning and connecting in real-time with historical knowledge and in a spanning way in one location enhances the students' grasp of historical information.

Another AR educational application called Virtuoso was developed by Wagner et al. (2006). The purpose of this educational game application is to sort a collection of artworks based on their date of construction along a timeline with three different methods: a PC, a personal digital assistant (PDA), and paper. According to Wagner et al. (2006), the results demonstrated learning outcomes were improved, and students paid more attention—a similar project is called the CONNECT, which utilises an AR-based system to aid students' learning in science. Students were required to wear a head-mounted display to perform experiments that were not possible in their school. The effectiveness of the CONNECT project on learners was evaluated by Arvanitis et al. (2009), and they found that the disabled students and non-disabled students had the same testing results which meant that AR has the potential to improve education even for students with disabilities.

Mad City Mystery is a location-based AR game developed by Squire and Jan (2007) to support learning in environmental science. Users search for information by using smart handheld devices for 90 to 120 min to help police to solve a murder mystery. The players investigate virtual characters who present possible scenarios. The educational aim of this AR game is to develop students' argumentative skills and investigation. The outcome of this study emphasised that AR, as an educational game, increases students' enthusiasm towards science.

The Magic Book is another AR application which uses a regular book, but the user can see 3D objects augmented in its contents. For example, DehAR book was designed to develop spatial skills among engineering students. This AR application presented 3D models by adding digital content that was required to accomplish spatial ability related tasks (Billinghurst et al., 2001). AR books, therefore, allow learners to see 3D contents while learning.

Another study was carried out on the use of GeoAR books in a classroom setting. GeoAR books display a printed marker in every page so the student can traditionally read the book and then use AR application to see some illustrations on various geometric forms like triangles, rectangles, circles. The results yielded positive results, and it was beneficial and attractive due to the animations based on AR, 3D, and audio illustrations of the objects (Kirner et al., 2012). In the Chemical Education field, an Augmented Chemical Reactions book was developed to support students in understanding Chemistry. The augmented book enabled students to see 3D spatial chemical molecules and manipulate and visualise the interactions (Maier & Klinker, 2013). Inorganic chemistry was also taught by using AR applications (Núñez et al., 2008), and the researchers indicated that AR tools help students to gain a better comprehension, understand the fundamental chemical concepts and structures and increases interest and attention in the learning process. This finding is confirmed by Maier et al. (2009) who stated that adopting AR technology increases the understanding of and attitude towards chemistry because teaching students with AR provides a more enjoyable way of controlling and interacting with spatial relationships between molecules which can lead to reducing apprehension in respect to chemistry.

Mobile AR applications (e.g. Aurasma) are another AR method which allows users to build and create AR educational contents in specific educational contexts, to share these experiences publicly and to store them in individual accounts as informational artefacts to reuse them as learning objects (Küçük et al., 2016). Overall, AR applications were designed to encourage teaching and learning by providing powerful features for students who have difficulty conceptualising complex information. Also, most of these research projects point out positive results related to increased motivation, collaboration, and deeper understanding.

2.3.5.2 AR in Higher Education

After the illustration of the potential use of educational AR technology in different fields, it can be seen that AR technology has a high education value; however, the higher education sector was much slower to address how AR could improve the learning process itself. Educational AR applications have recently flourished in a significant way from primary and secondary education to the higher education levels, and in both the private and public sectors, in formal and informal education places. In The Horizon Report 2016: Higher Education Edition, AR was described as an immersive technology providing students with “deeper levels of cognition” by new content viewpoints (Johnson, 2016, p. 40). Many applications have been introduced in higher education, to help students comprehend chemistry, mathematics, mechanical engineering, electronic, and physics concepts (Munnerley et al., 2014). AR in physiology and anatomy, for instance, Küçük et al., (2016) cited that the human body is visualised in 3D to allow the student to see from different angles and enhance their understanding.

AR was also used in chemistry to support students to understand and visualise the spatial structure and relationships between molecules and interact with 3D virtual objects (Maier & Klinker, 2013). AR is considered an effective technology for higher education, such as colleges and universities (Lee, 2012). According to a recent report, Akçayır and Akçayır (2017) evaluated 68 research articles in a systematic review of what learner types participated in studies related to AR use in education. The findings of Akçayır and Akçayır (2017, p. 5) confirmed that the second most frequent type of student was university students (29%).

Furthermore, the learning of a complex concept in mechanical engineering in higher education was facilitated by using (Liarokapis & Anderson, 2010). According to Liarokapis et al. (2004), difficult theories and complicated mechanisms in higher education can be better understood and accepted by learners after using AR technology. "AR supports the understanding of complex phenomena by providing unique visual and interactive experiences that combine real and virtual information and help communicate abstract problems to learners. With AR, designers can superimpose virtual graphics over real objects, allowing users to interact with digital content through physical manipulation. The result is a more effective demonstration of spatial and temporal concepts, as well as of the contextual relationships among real and virtual objects. For example, students can abstractly understand the earth's position relative to the sun by reading text and seeing a 2D picture, but they can better grasp the nuances of that position by visualising a 3D solar system. Dynamic processes become animated models, and direct tangible interaction provides an intuitive way to interact with the digital content." (Billinghurst & Duenser, 2012, p. 56).

Santos et al. (2014, p. 40) studied the impact of integrating AR technology on student outcomes in higher education. The result of this study showed that "the mean effect size of technology applied to higher education remains to have a wide variability around 0.28 or low to the moderate effect". Research on the effect of AR technologies in science laboratories on attitudes towards laboratories and university laboratory skills of students highlights the fact that AR enhanced the students' laboratory skills and assisted them in building positive attitudes towards laboratories of physics (Akçayır et al., 2016). They also revealed that low technological experience among students and teachers and poor Wi-Fi Internet service in the institution could lead to adverse outcomes.

The effectiveness of AR technology in higher education has been exemplified in a study by Küçük et al. (2016). Higher academic achievement and lower cognitive load resulted from integrating an AR application in teaching undergraduate medical students. According to student opinion in that study, 79% of them agreed that AR facilitated their learning of the topics. However, designing the learning content, such as 3D multimedia, was a substantial obstacle in integrating AR in that study, and this factor needs to be considered in adopting AR in high education.

Safadel and White (2017) conducted a study among undergraduate and graduate students from Texas Technical University to compare the use of AR and two-dimensional structures in the instructional environment. The result illustrated that AR technology facilitates students' learning, interaction, and helps the students with low spatial abilities to improve satisfaction towards Science, Technology, Engineering and Mathematics (STEM) courses. Garcia et al. (2010, p. 29) commented on integrating AR into higher education "the possibilities that this technology can offer in higher education remain to be discovered and depend on what we are able to imagine and devise as pedagogical applications rather than on the possibilities provided by the technology itself."

AR-based paper marker material has been used by Bendicho et al. (2017) to explore the effect of using AR technology on academic procrastination for engineering students. Results indicated that students' academic procrastination was decreased via using AR. Regarding students' anxiety towards mathematics in higher education, it was confirmed by Salinas et al. (2013) that AR could reduce students' anxiety through understanding mathematical knowledge with AR methods. Spatial orientation can also be developed when using AR technology. Engineering students' spatial orientation was observed by Carbonell Carrera and Bermejo Asensio (2017) when they utilised AR marker-based material on paper. According to their results, employing AR in the engineering field promoted students' spatial orientation skills.

2.3.5.3 Affordances of AR in Education

Before integrating a new teaching method into a learning setting, lecturers must consider the reason for doing so (Smith & Ragan, 2005). The potential educational use of AR was discussed by Munnerley et al. (2012), and they suggested that the application of formal educational AR should be embedded within a broader framework that specifies how learning happens, using it to promote reflection, questioning, collaboration, and critical thinking. Improvement of student learning qualities such as motivation, the achievement of learning, engagement, satisfaction, and attitude are advantages of educational AR use based on most of the study outcomes (Di Serio et al., 2013; Estapa & Nadolny, 2015; Ferrer-Torregrosa et al., 2015; Küçük et al., 2016).

Students are positive about AR-enhanced learning activities when they adopt AR in their studies (Lu & Liu, 2015). They show enjoyment and playfulness as they are learning using AR. The improvement in the learning performance of students was also another benefit of using the mobile device AR approach in teaching (Chiang et al., 2014). According to Chiang et al. (2014), relevant materials (e.g., images, texts, videos) should be well-incorporated and prepared in designing AR to improve the students' learning performance and prevent incidental cognitive loads. Several authors (Bujak et al., 2013; Cheng & Tsai, 2013; Dunleavy et al., 2009; Radu, 2014; Wu et al., 2013) have pointed out that AR has potential educational affordances that are particularly useful in the fields of STEM, including theoretical understanding, scientific inquiry, spatial skills, and practical skills. Also, Faith (2019) contended that learner interaction, collaboration, cultural exploration and digital storytelling are other affordances offered by the AR technology in higher education.

Motivation in learning is a significant factor that might positively enhance learning outcomes (Schunk, 1991). Between 2003 and 2013, Bacca et al. (2014) reviewed 32 AR studies in education and found that the factors that are most frequently associated with AR learning are better performance and motivation of learning. AR technology is considered a learning tool that develops students' self-efficacy to search for related information concerning their learning content on their own (Chiang et al., 2014). Also, students can be guided through learning by AR technology when direct and relevant information overlays the learning components, which may increase students' learning motivation. A study by Bujak et al. (2013) which compared AR and traditional computer devices inside and outside a mathematics classroom suggested that AR as a collaborative learning tool will create more motivation among students to learn more effectively. AR allows learners to interact with virtual objects in the real world. Therefore, AR technology offers better opportunities for learning regarding physical movements in rich sensory spatial contexts (Dunleavy et al., 2009). "At this early stage of AR research, its most significant affordance is the unique ability to create immersive hybrid learning environments that combine digital and physical objects, thereby facilitating the development of process skills such as critical thinking, problem-solving, and communicating utilised through interdependent collaborative exercises" (Dunleavy et al., 2009, p. 20).

Many studies reported the different effects of using these technologies on students' learning outcomes. For instance, a study by Wojciechowski and Cellary (2013) shows that AR technology can provide students with the better motivation to learn. AR has been hypothesised by Bacca et al. (2014) to be a useful learning tool owing to its combination of the actual world with the virtual objects or its superimposition of information and through enabling the visualisation, exploration, manipulation and interaction of objects within a computer-generated surrounding; this allows for learning discovery at a suitable pace. AR has been confirmed by findings to encourage positive learning experiences that positively influence students' learning in the faculty of medicine and science (Barrow et al., 2019; Barsom et al., 2016). AR also provides enjoyment, which plays a significant role in determining students' intention to use this technology in the future.

Furthermore, Jou and Wang (2013) found that teaching approaches that integrate AR have the most effect on students' motivation to learn. From the psychological perspective, Bujak et al. (2013) identified the psychological factors that enhance a learning environment that uses AR: students can interact naturally, and this can lead to an increase in the transparency of the interface between students and educational content. Additionally, Bujak et al. (2013) concluded that the AR environment could enhance learning by attaching data to objects and locations in the students' surroundings.

The level of satisfaction was measured among students and teachers in most of the studies related to educational AR (Cai et al., 2016; Di Serio et al., 2013; El Sayed et al., 2011; Estapa & Nadolny, 2015; Fonseca et al., 2014; Kamarainen et al., 2013; Wojciechowski & Cellary, 2013). In the results of these studies, enormously high levels of satisfaction and positive assessments have been found. Furthermore, several studies have concluded that immersing students in AR-based learning environments lead to an enhancement in students learning outcomes (Albrecht et al., 2013; Cai et al., 2016; Hayes et al., 2013; Kamarainen et al., 2013; Sytwu & Wang, 2016). Combining educational content with AR technology builds new automated applications to enhance the effectiveness of learning and teaching results. “Augmented reality has strong potential to provide both powerful contextual, in-situ learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world” (Johnson et al., 2010, p. 18).

Bujak et al. (2013) discussed how AR allows students to interact naturally, which can enhance learning by attaching data to objects and locations in the students’ surroundings. Fonseca et al. (2014) outlined the advantages of AR in architecture education. They found that the AR tool helps to increase students' spatial perception and allows students to integrate views of hypothetical situations into future construction spaces.

Martín-Gutiérrez et al. (2012) introduced the use of AR applications in education for the teaching of electrical engineering to develop students' self-learning ability; the results showed that AR increased students’ self-learning ability and prevented the need for repeated explanations. Another study by Kamarainen et al. (2013) assessed the use of AR technology to aid students’ understanding and interpretation when measuring water quality. The results show that AR allowed students to interact in real-time, and that leads to improvement in interpretation flexibility. Likewise, AR was introduced to education by Tarng and Ou (2012) to teach the students about the butterfly's life cycle in a virtual way, and the result was impressive. They found that AR increases students’ interest in learning. Also, Akçayır and Akçayır (2017) demonstrated that most of the advantages of AR in educational settings relate to students' learning outcomes such as motivation, attitude, and learning achievement.

Current research on the use of AR as a learning tool highlights the fact that AR technology reduces the level of mental effort and mental load. Furthermore, AR is considered a helpful learning tool, increases the students’ intention to learn and their motivation (Cheng, 2017). Several advantages of AR in an educational setting were identified by Sirakaya and Kiliç Çakmak (2018) like increasing students’ motivation to attend classes, attracting students to learn, facilitating comprehension lessons, concretising abstract concepts, supporting authentic learning and developing students’ creativity. AR provides one of the most excellent benefits to education by increasing accessibility to virtual educational content. Students can access virtual content via computer devices such as desktops and laptops or mobile devices such as tablets and smartphones which allow the student to reach the virtual educational content by directing a camera at the surrounding environment. This is very useful for students since contextually-relevant information can be obtained to meet the student's interests.

2.3.5.4 AR and Learning Styles

Information is taken in and processed by students in different ways like reflecting, acting, analysing, seeing, reasoning logically, hearing and visualising (Bhattacharyya & Shariff, 2014). According to James and Gardner (1995), learning styles is how people learn in different patterns. Instructors demonstrate various teaching methods, and these methods need to be matched with the learning style of a student otherwise, the students may not attend the class, may achieve low marks, become bored, and might drop out of school. The idea of learning styles was shaped on cognitive psychology. There are a variety of cognitive features that some researchers have attributed in higher education to learning styles (Durling, Cross & Johnson, 1996; Newland, Powell & Creed, 1987). Educational AR can be used to transfer traditional learning methods to a participatory approach and active learning. Students will then have the freedom to experiment and develop other learning styles. AR supports different learning styles:

- **Visual:** AR provides digital objects in 3D like moving images, graphs, models, and charts which makes the concept or solving an issue in learning easily understandable. Students are also able to interact with these objects and view them from different angles. Zhang et al. (2016), points out that AR can be particularly appropriate for students who have strong visual kinesthetics' interaction preferences.
- **Auditory:** Including recorded materials and audio is one of the AR abilities that may benefit learners when they interact with lesson materials (Mayilyan, 2019). Students can listen to instructions explaining any topic.
- **Kinesthetic:** Kinesthetic education is a learning style in which students learn by doing physical activity, instead of watching a demonstration or listening to

a lecture (Wehrwein et al., 2007). With AR, students can learn by moving around, doing activities, manipulating and touching their environment.

Generally, the number of cognitive processes is increased when students are engaged in in-depth learning. Students can learn and develop many cognitive processes with AR, such as problem-solving, abstract thinking, remembering, understanding and analysing (Liu et al., 2004).

2.3.5.5 AR and Pedagogical Theories

Implementing technologies such as AR the learning setting can be supported by learning theories to provide a heuristic guide for instructors (Wang et al., 2018). Theory of learning is grouped into one of many epistemological viewpoints or paradigms. This section will cover the educational theories that relate to the core educational functions of AR. Based on the literature, AR technologies can fit and support a variety of educational theories (Johnson et al., 2010; Shelton & Hedley, 2002). AR can support the following theories:

- **Situated learning:** Jean Lave and Etienne Wenger (1991) revealed situated learning in the early 1990s. It is about learning by actively contributing to the learning experience. Additionally, it was suggested that teachers can more effectively integrate technology into pedagogy by the utilisation of technology where teaching and learning occur (Bell et al., 2013). The importance of placing students in a learning setting that is supported with both digital resources and real-world learning objects has been emphasised by some previous research (Chin et al., 2015; Hui-Chun, 2014). AR supports situated learning by merging the real-world situation with educational experiences and by transporting the actual world into the classroom (Cheng & Tsai, 2013; Dede, 2009; Dunleavy et al., 2009; Rasimah et al., 2011). AR offers students the chance to achieve results at a high level.
- **Games-based learning** is implementing games for education. In the early 1980s, game-based learning started and has gradually grown and evolved (Johnson et al., 2011). Game-based learning approaches have been recognised as positive teaching and learning strategy that might assist

students in difficult thinking tasks, combining several tools and resources. Students learn by doing and being guided through their learning by stories and into a way of thinking (Barab et al., 2005). Recently, the digital game-based learning method has gained much interest (De Bie & Lipman, 2012). Previous studies (Brom et al., 2010; Dunleavy et al., 2009; Klopfer & Squire, 2008; Squire & Jan, 2007) suggested that AR systems could be used to change the real-world environment into games that are played by placing students in a role, to acquire knowledge and transfer skills to real-life applications.

- **Enquiry-based learning:** AR provides learners with the tools and the thinking processes needed to develop inquiring minds by offering resources to electronically collect information for further analysis (Dunleavy et al., 2009). Additionally, AR can offer virtual models that can be easily manipulated and placed in a real-world situation (Kaufmann & Schmalstieg, 2003). Johnson et al. (2010) stated that AR could support enquiry by adding contextually-relevant information to the investigated topic.

- **Constructivist learning**: AR enables students to participate more with learning tasks as they are interacting with information, resources and concepts that overlay on the real environment (Kerawalla et al., 2006). By using AR, students control their learning and acquire understanding and knowledge through manipulating virtual objects. Implementing AR in teaching and learning ensures the learner is involved in authentic inquiry and active observation (Champney et al., 2015). AR coincides with a learning theory of constructivism. "AR is primarily aligned with situated and constructivist learning theory, as it positions the learner within a real-world physical and social context while guiding, scaffolding and facilitating participatory and metacognitive learning processes such as authentic inquiry, active observation, peer coaching, reciprocal teaching and legitimate peripheral participation with multiple modes of representation" (Dunleavy & Dede, 2014, p. 735).

- **Connectivism** is a recent theory of learning endorsed by Stephen Downes and George Siemens (Downes, 2010; Siemens, 2005). This theory arose in the age of internet technologies and is called a digital age learning theory. It refers to how people can create new opportunities for learning and sharing online information technologies among themselves (Downes, 2010). These technologies, including any tools that allow users to be learning and knowledge sharing with other people. Learning becomes ubiquitous in the digital era. Based on connectivism theory, knowledge can be accessed outside the individual, and learning is not a purely internal process anymore (Siemens, 2017). Thus, AR supports this theory by allowing learners to obtain immediate access to appropriate information for learning promptly. Wang et al. (2018, p. 4) report that "AR expands previous concepts of how and when information is accessed, and knowledge is stored, exemplifying connectivism".

2.3.5.6 Engaging Teachers with AR

Incorporating AR technology into the learning environment is not going to displace the existing pedagogical pattern. The pedagogy is an essential future resource. Understanding the differences between pedagogy, technology, and content is an essential part of creating learning environments (Mishra & Koehler, 2006). In the Technological, Pedagogical and Content Knowledge (TPACK) Framework of Mishra and Koehler (2006), the three domains dynamically interact with each other. AR technologies promise to improve higher education learning outcomes (Vega Garzón et al., 2017), and they belong to the type of simulation-based learning (Lateef, 2010). AR in higher education can be analysed in the TPACK framework. Figure 15 illustrates the model, which includes three main teacher knowledge components: pedagogy technology and content.

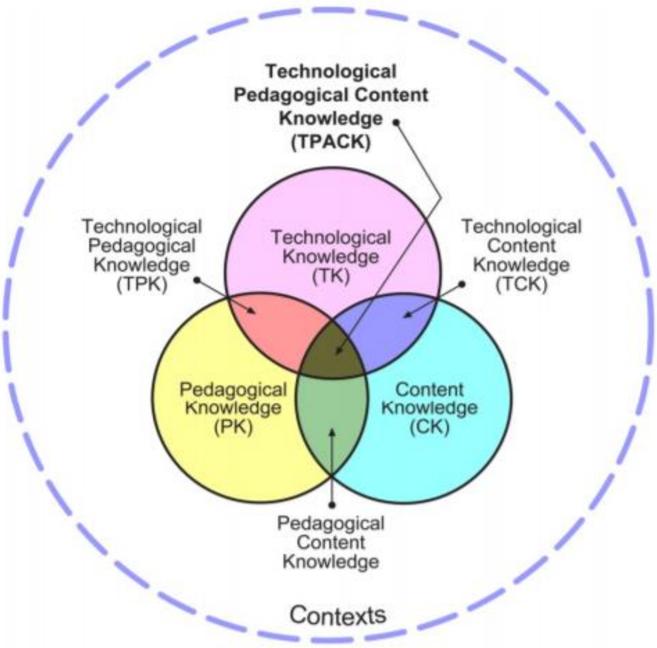


Figure 15. The Technological Pedagogical Content Knowledge (TPACK) model; (Munnerley et al., 2014)

All these components are equally essential to the framework, and the relations between these forms of knowledge is demonstrated as technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical content knowledge (TPACK), and technological pedagogical knowledge (TPK). The TPACK theoretical framework has reshaped the current understanding of knowledge that is required by expert teachers. Mishra and Koehler (2006) highlighted that the acquisition of knowledge in these three dimensions is required to train teachers to use these curricular instruments. Integrating AR technology in education will be most effective when teachers understand how different platforms enable them to represent content in various ways.

Before integrating a new approach of teaching into a learning setting, teachers have to consider why they want to use that approach (Smith & Ragan, 2005). AR promises to supplement the learning environment with instructional and pedagogical learning methods (Billinghurst & Duenser, 2012). An AR study by Bacca et al. (2014) produced outstanding results and encouraged researchers to study the use of AR in education. The results showed that the area of "education" (teacher training) had not been investigated. One of the promising roles of AR is increasing teachers' efficiency in education by helping the teacher to explain information more efficiently. For instance, a lesson about Ancient civilisations will be difficult if it does not have material that students can see as they have no experience to connect the information to. With AR techniques, teaching becomes practical and more natural with viewing 3D contents.

2.3.5.7 Pedagogy and Learning Design with AR

Watkins and Mortimore (1999, p. 17) defined pedagogy as "any conscious activity by one person designed to enhance learning in another". There are many applications of ICTs in education, such as virtual laboratory environments, virtual classrooms, and cyberspace learning environments. Häkkinen and Hämäläinen (2012, p. 235) indicated that "We should move away from assessing operationalised, routine kinds of tasks and easily measurable knowledge and skills, and focus on assessing how students use technologies as thinking tools in order to search, produce, manage, analyse, and share knowledge as well as solve complex problems individually and collaboratively". Bower and Sturman (2015) argued that wearable technologies in higher education such as AR offer pedagogical contributions to enhance educational quality through engagement, presence, and efficiency as well as including the ability to provide a first-person view, in-situ contextual information, in-situ guidance recording, simulation, communication, feedback, distribution and gamification.

Logistical implications are also other pedagogical contributions of wearable technologies which offer to free up spaces and hands-free access (Bower and Sturman 2015). The pedagogical potential of AR in learning and teaching can be determined through collaboration and experience, learning environment, objects representation, and the cost of error. According to Munnerley et al. (2012, p. 45) "AR offers several exceptional pedagogical opportunities:

- Mobility.
- Visualisation (which may be manipulated by the viewer).
- Alternative perspectives.
- Comparison of and contrast between multiple perspectives.
- Integration of multiple perspectives".

AR-based learning methods, from a pedagogical perspective, enables collaborative learning and enhances the natural interaction to convey spatial cues. Also, AR, as a learning tool, provides a navigated and easy to use interface (Chen, 2006; Shelton & Hedley, 2004). With AR, students can learn in a physical space and experience different environments such as a remote outdoor environment and an enclosed area. Another pedagogical potential is that AR can also create a social learning environment; for example, students can learn everything vicariously before they learn it directly and interact with their social teams.

Learning is considered a social practice. Knowledge occurs through communities; consequently, positive learning outcomes involve the ability of learners to participate in those practices successfully. Most AR technology relies on sharing with peers. Furthermore, the learning concept and objects are presented in three dimensions, including tangible physical objects and can be easily manipulated. AR in learning allows students to make mistakes without compromising the safety of themselves or other students. "The power in AR, which sets it apart from traditional curricula and even from purely virtual learning environments, lies in truly augmenting the physical landscape using digital technologies to enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected" (Klopfer & Sheldon, 2010, p. 86).

2.3.5.8 Student-Centred Learning and AR

Student-centred learning (SCL) was defined by Cannon and Newble (2000, p. 16) as "ways of thinking and learning that emphasise student responsibility and activity in learning rather than what the teachers are doing. Essentially SCL has student responsibility and activity at its heart, in contrast to a strong emphasis on teacher control and coverage of academic content in much conventional, didactic teaching." SCL might be the core reasons for technology-enhanced student learning outcomes. Nowadays, the new generation of students are very digitally experienced, and despite different students backgrounds (culturally, demographically), different digital skills are acquired (Kukulska-Hulme, 2012). According to Kamarainen et al. (2013), SCL can be supported by AR that provides a powerful educational tool with enormous benefits to students learning.

The incorporation of AR enhances student-centred activities. Furthermore, Cheng and Tsai (2013) indicated that AR is mostly useful when students have a certain experience level of technology, and a degree of autonomy especially found with students at the middle school or high school level. AR technology enhances the learning environment to be student-centred and delivers a new chance for teamwork that raises the level of understanding of the content. Kamarainen et al. (2013, p. 554) noted that "these technologies provide ways of individualising instruction in a group setting, fostering increased motivation and learning" which "freed the teacher to act as a facilitator."

Furthermore, Diegmann et al. (2015) indicated that AR supports SCL environments by enabling students to solve problems and explore knowledge autonomously. These studies show that AR applications contribute to SLC methods by offering new possibilities to instructors to individualise their teachings depending on students' capabilities and by empowering students to learn independently.

The following review (i.e. 2.4, 2.5, Section 2.7, and Section 2.8) will discuss the key themes emerging in technology incorporation, especially AR, as an educational tool in developed and developing nations and summarises many studies that have suggested frameworks and models for implementing AR. By incorporating the most significant factors emerging from the existing literature, this work aims to create a comprehensive and reliable collection of factors that could be useful in the effective adoption of AR technologies in SA's higher education system.

2.4 AR Incorporation in Developed Countries' Education Sector

A large number of studies of adopting and implementing AR at different levels in schools, colleges, and universities in developed countries were conducted. Different areas have been included, including education, nursing, industry, IT, language learning and employee training. In Table 2, the literature shows several educational AR implementations in developed countries with considered factors.

Table 2 brings together the key common factors that most AR studies in developed countries considered. Developing and developed countries have their perspectives and purposes for educational reforms and adopting innovative technologies. The considerable disparities between these countries such as economic, political, and social factors, may facilitate or avert a successful integration of any technology and the gap between them is related to the lower levels of skills and capital intensity (Woolf et al., 2011). Developed countries are more capable of adopting new technology than developing countries because of their resources, experience, knowledge, and skills.

Table 2: Studies of AR in education in developed countries

Authors	Methodology	Factors considered	Country
(Barroso-Osuna et al., 2019)	A questionnaire with 264 subject experts	Teacher training and improvement, conceptual foundation, educational research, institutional support, teacher attitude/belief for incorporation, technological/economic.	Spain
(Safadel & White, 2017)	Survey	Self-efficacy, spatial ability, lesson activities, recognition memory, satisfaction.	USA
(Carbonell Carrera & Bermejo Asensio, 2016)	Experiment	Spatial thinking, age, gender.	Spain
(Akçayır et al., 2016)	Mixed-method A quasi-experimental pre-test/post-test A questionnaire +A semi-structured interview	Laboratory skills, physics laboratory attitude, willingness.	Turkey
(Albrecht et al., 2013)	Questionnaire	Usability, emotional involvement, learning outcomes (learning efficiency).	Germany
(Carlson & Gagnon, 2016)	Online survey	Critical thinking, engaging, interaction, enhanced learning, enhanced simulation, assisted learner to understand.	USA
(Chin et al., 2016)	The questionnaire surveys A quasi-experimental research design	Students' perceptions, cognitive abilities, teachers' willingness, teachers' attitude, easy to use.	Taiwan

Authors	Methodology	Factors considered	Country
(Küçük et al., 2016)	Mixed-method (University)	Effects of AR in learning, achievement, cognitive load, experience, learning satisfaction, students' opinions, engagement, learning performance.	Turkey
(Coimbra et al., 2015)	Survey	Perceptions, practices of students.	Portugal
(Lee et al., 2015)	Surveys	Aesthetics of AR, perceived enjoyment, cultural difference, acceptance, beliefs, perceived usefulness, perceived ease of use, behavioural intention.	Korea
(Lin et al., 2015)	Qualitative and quantitative Pre- and post- System-assisted learning	Achievements, performance in spatial perception, efficiency, system usability, system task load, attitude, willingness.	South Korea and Ireland
(Bower et al., 2014)	A case Study of "learning by design"	Thinking capabilities, critical analysis.	Australia
(Estapa & Nadolny, 2015)	A quasi-experimental design Pre-test, post-test, Survey	Technical, conceptual understanding, motivation, attention, satisfaction, learning experience, engagement.	USA
(Martín-Gutiérrez et al., 2015)	Survey	Acceptance, collaborative, useful, usability, ease of use, satisfaction.	Spain
(Delello et al., 2015)	Pre- and post-experience surveys	Perceptions of students, usability, student attitudes of AR as a pedagogical tool, enhancing learning, interest, field of study.	USA
(Fonseca et al., 2014)	A case study. Pre-tests and post-tests	Feasibility of using AR, usability, student participation, improvement in academic, performance, motivation, satisfaction, efficiency, useful.	Spain

Authors	Methodology	Factors considered	Country
(Chiang et al., 2014)	Quantitative Experimental study	A sequential behaviour, a sequential learning process, cooperative learning.	Taiwan
(Bressler & Bodzin, 2013)	Mixed-methods approach Pre-survey - post-survey Group interview	Students' engagement, interest in science, gaming attitude, flow experience, gender.	USA
(Di Serio et al., 2013)	Case study Quantitative Qualitative observation	Motivation, attention, satisfaction, confidence, usability, learnability, efficiency.	Spain
(Hayes et al., 2013)	Mixed-methods	Efficacy, user experience, learning outcomes, suspension of disbelief.	USA
(Kamarainen et al., 2013)	Surveys	Student attitudes, content learning gains, teachers' opinions, learning and motivation, usability.	USA
(Wojciechowski & Cellary, 2013)	Questionnaire	The attitude of learners, technology acceptance, perceived enjoyment, interface style constructs, perceived ease of use, perceived enjoyment, intention to use, perceived usefulness.	Poland

To continue the discussion on the list of scientific articles as provided Table 2, the table was analysed using NVivo software 12 (Word Cloud) to identify the most frequently considered factors by researchers of AR studies in developed countries. Figure 16 shows the commonly considered factors in developed nations.

Despite many studies that have been conducted, these studies have not examined the social and cultural factors in AR learning environments. Instead, as can be noted in Figure 16, these studies have focused on AR effectiveness on students, technical issues, usability, perception, attitude, and technology usefulness. Although AR projects are being used in many developed countries' education sectors, developed countries have not been utilising AR projects. Technology integration in the educational context requires an implementation plan, based on the organisation's needs, to achieve higher acceptance and support, both financially and philosophically, from all stakeholders (Levine, 1998). Therefore, extracting and evaluating the information in the articles regarding implementing educational AR in developed countries assists in developing the conceptual AR framework by including these factors.

Figure 16: Factors considered in developed countries by researchers in AR studies (Prepared by author)

2.5 AR Incorporation in Developing Countries' Education Sector

In contrast with developed nations, adopting innovative technology in developing countries needs more work to keep up with emerging IT to aid education. Some barriers have been encountered by universities in developing countries as they search to implement educational technology, and there have been some challenges to using ICT effectively. In one example from Africa, institutions in Tanzania are struggling to implement ICT because of the inadequate systematic approach, attitudes and awareness towards technology, low administrative and technical assistance, higher education transformation, development of staff, mismanagement, and low funds (Sife et al., 2007). These factors should be considered when planning to incorporate technologies in the learning and teaching process in a developing context. Additionally, according to Sharma (2003), integrating ICT in the education sector in developing countries depends mainly on policy planning by the governments. Sharif et al. (2018) highlighted the factors and possible opportunities for adopting AR in education in a developing country. They found that the main challenges are the financial crisis, lack of technical knowledge, and the traditional system of education that may impede the process. At the same time, the key opportunities for AR adoption are fast internet, usability, 4G evolution and efficient learning experiences.

Albirini (2006) acknowledged that cultural factors are one of the essential elements in integrating technology in developing countries. Human factors such as gender issues, cultural differences, and the social environment, require consideration to meet the challenge (Sharma, 2003). Therefore, integrating AR technology especially in education in the developing world is less common than developed nations due to these and other concerns such as economic, political, and social factors (Sife et al., 2007). Some educational AR studies have also been conducted in developing countries and identified from the literature. The literature presented in Table 3 shows many implementations of educational AR in developing countries with considered factors.

Table 3: Studies of AR in education in developing countries

Authors	Methodology	Research Outcomes	Factors Considered	Country
(Ahmad Fauzi et al., 2019)	The questionnaire pre-test and post-test results	Determined students' readiness to use AR in teaching; (2) determined what they expect when using AR in construction technology; (3) determined whether students accept AR in learning.	Readiness, student's acceptance, effectiveness of AR.	Malaysia
(Sharif et al., 2018)	Questionnaire	Identified challenges and opportunities to adopt AR in developing countries.	Smart devices, faster internet, usability, 4G evolution, effective learning experience, technical knowledge, financial crisis.	Bangladesh
(AlNajdi et al., 2018)	Questionnaires	Evaluated learning effectiveness with AR using a Pedagogical Virtual Machine (PVM). The PVM approach with AR was more effective than a paper-based approach for learning performance, learning activities and utility.	Learning effectiveness, usefulness, enjoyment, competence in the activities.	Saudi Arabia
(Georgiou & Kyza, 2017)	Survey	Observed high school students' immersion in AR location-aware settings.	Immersion, cognitive, emotional, enjoyment, engagement.	Cyprus
(Cheng, 2017)	Quantitative survey	An AR book was adopted to study the cognitive load, motivation and attitudes of users in the context of AR learning.	Cognitive load, motivation, attitudes, perceived control, perceived usefulness the behaviour of learning, the behaviour of AR learning	China

Authors	Methodology	Research Outcomes	Factors considered	Country
(Alkhattabi, 2017)	Questionnaire	Evaluated, as an initial experiment, the acceptance by teachers of AR applications in an e-Learning environment. Identified the main obstacles and advantages of AR technology adoption.	Infrastructure, willingness, acceptance, culture.	Saudi Arabia
(Miranda Bojórquez et al., 2016)	A survey	Developed a Loter'ıa Mayo MAR system to support Mayo language learning.	Culture, TAM items, individualism, uncertainty avoidance.	Mexico
(Cai et al., 2016)	Experiment Quasi-experimental study Questionnaires and interviews	Observed learning attitude and learning result from the implementation of AR-based motion-sensing apps.	Design, implementation, learning attitude, learning outcome, the teaching method, students' satisfaction, acceptance level, attitude.	China
(Alsowat, 2016)	Quasi-experimental approach Experimental Questionnaire	Investigated the effect of AR on reading comprehension, self-efficacy, autonomy and attitudes of college EFL students.	Students' self-efficacy, autonomy, attitudes, training, motivation, evaluation, aptitudes.	Saudi Arabia
(Gopalan, 2016)	Questionnaires	Developed a conceptual model to design and development of the estar application. Enhanced science textbook utilising AR (eSTAR) with multimedia elements including text, audio, video, graphics, animation and 3D objects.	Ease of use, engaging, enjoyment, fun on students' motivation.	Malaysia

Authors	Methodology	Research Outcomes	Factors considered	Country
(Xiao et al., 2016)	Mixed-method	Designed Integrated Design Model for the U-learning environment and a technology-based learning system for AR called Starry Sky Exploration — Eight Solar System Planets was been developed.	Learning effectiveness, learning experience, learners' characteristics.	China
(Bazzaza et al., 2014)	Survey	Evaluated group of students and teachers of the effectiveness of AR technique. Suggested proposals for system development.	Pedagogical factor, user experience, technological factor.	United Arab Emirates
(El Sayed et al., 2011)	Questionnaire	Developed an innovative ARSC system to reduce educational expenses in schools and improve the visualisation capacity of students with limited resources.	Satisfaction, implementation, visualisation ability, education expenses, AR efficiency.	Egypt
(Sumadio & Rambli, 2010)	Qualitative and Quantitative research design	The effectiveness of the AR application in particular in the learning environment was examined and the usefulness of the AR application in education was determined.	Implementation, usefulness, acceptance, usability.	Malaysia
(Pribeanu & Iordache, 2008)	Quantitative and qualitative	Observed usability of AR-based Chemistry learning scenario focusing on motivational value.	Usability, motivation, learning experience, enjoyable, acceptance model, age and gender.	Romania

As can be seen in Table 3 and Figure 17, the cultural background of the country and the extent of its effect on the AR implementation in that particular country were studied by some participants in developing countries (Alkhattabi, 2017; Miranda Bojórquez et al., 2016). Cultural factors in developing nations such as ethnicity are other barriers in using technology in education and must be recognised and examined before the implementation stage.

Figure 17: Factors considered in developing countries by researchers in AR studies (Prepared by author)

Overall, the data evaluation of the previous researches, included in Table 2 and Table 3, sought to explore the AR implementation in the education sector in both developed and developing countries to understand the successful integration of AR better and gain insights into the factors that inspire the adoption of AR in appropriate ways. Most of the research in developing countries was focused on AR adoption factors. For example, the technological infrastructure and knowledge, and the financial support of the institutions were more of a concern for AR implementation in the developing countries compared to developed countries.

Therefore, in this study, the researcher will consider the identified factors in both developed countries (technical issues, training, usability, perception, and technology usefulness) and developing countries (cultural background, technological infrastructure, and the financial support) and combine these factors in the framework to contribute to successful adoption of AR technologies in SAn universities.

2.5.1 Integration of technology in Saudi Arabian Universities

The integration of technology in universities is rapidly increasing to simplify the delivery of education. Therefore, to enhance student learning, a large number of studies have been focused on finding better technological solutions that are compatible with pedagogy (Goos, 2010; Lee & Hollebrands, 2008; Zakirova & Purik, 2016). Collaborative E-learning is one of the popular pedagogical technologies that was integrated into Saudi Universities to improve education. Al Saif (2005) indicated that Collaborative E-learning plays a significant role in increasing the number of students enrolling at universities. Smart Tablet technology was introduced in SAn education, and it enhanced student learning outcomes by increasing the level of engagement in the learning process (Almalki et al., 2013). Several studies (Badwelan et al., 2016; Nassuora, 2012) examined the acceptance by students in SA of mobile learning in higher education. The results of Badwelan et al. (2016, p. 26) revealed that "more than 65 per cent of students were using online learning services, and more than 62 per cent were learning by electronic resources daily. Smartphones, iPads, and Tablets were the preferred learning devices of 56% of students."

However, several studies (Al-Alwani, 2005; Al-Jarf, 2005; Almalki et al., 2013; Amoudi & Sulaymani, 2014) identified limitations: delay of the integration or rather the implementation of these technologies in SA education; the lack of a proper infrastructure; and the culture and personal beliefs, which have a significant impact on utilising technology in classrooms. The SAn economy is competing with the global marketplace by utilising the innovative and effective use of technology.

Despite the learning and teaching issues in the Saudi education system, there are also many reasons for optimism. The Ministry of Higher Education is continuously conducting studies in SA to develop an adequate E-learning infrastructure. Alrasheed et al. (2003) reported that in developing countries such as SA, many universities and schools depend on traditional teaching methods and ignore more effective methods such as the use of technology in the classroom. A National Centre of E-learning and Distance Learning was established in 2008 in SA to improve and support the growth of E-learning in Saudi universities (Alkhalaf et al., 2013). Al-Jarf (2005) argued that the system of education in SA needs to be developed to use alternative teaching methods and increase the teachers' awareness of using technology in the classroom. Consequently, SA allocated a massive budget to support the growth of the education sector and introduce new education programs (Council, 2009). One of the most significant projects to redevelop the education sector in SA is the King Abdullah University of Science and Technology (Agarwal et al., 2013). This project aims to redevelop and improve the learning environments by integrating a digital environment and technologies into the classroom. The Ministry of Education has established 27 technical centres to develop teaching methods and improve teachers' performance in class (Amoudi & Sulaymani, 2014).

In 2014, EON Reality and Midwam businesses opened a new Interactive Digital Centre in SA to power the use of VR and AR tools in industrial and educational needs (EON, 2016). The SAn Government aims to use technologies to improve education for Saudi youth. In the year 2030, the aim of the SAn Government to have at least five Saudi universities in the top 200 universities worldwide (Saudi Vision 2030, 2016).

Although there are some individual efforts to implement AR in SA education, it is not yet clear to what extent and how SA's higher education system can integrate AR into education. In this study, a framework will be developed to help introduce AR technology into the higher education system in universities of SA; then, this framework will be evaluated, taking into account previous restrictions.

The orientation of the SAn 2030 Vision is making the population more actively involved in the digital economy by demanding more people to be ICT literate and acquire the necessary skills of ICT (Thompson, 2019). Therefore, SA is providing a large budget for developing ICT specialists who can create, build, deploy, and maintain ICT systems as well as introducing more recent innovations such as 3D printing, robotics, cognitive systems, AR/VR.

2.5.2 Learning Technologies in SA

Abou-Elhamd et al. (2010) examined the adoption of VR in medical education in SA. Students used the Voxel-Man TempoSurg simulator to learn about the anatomy of the temporal bone in three dimensions. They found that teachers and students consider the virtual environment as being a powerful learning tool. Colbran and Al-Ghreimil (2013) investigated the teaching technologies used by academics in their courses. The results indicated that a variety of technologies are being tried, such as smart electronic boards, learning management systems, and Virtual Worlds. Another learning technology used in SA higher education is a virtual Avatar to represent a female tutor in online learning (Adham et al., 2016). The Avatar technology was used to resolve the issue of a gender-segregated society in online learning. Based on that study, virtual Avatar is considered as a right learning technology for both male and female students. Nevertheless, certain limitations can prevent the adoption of these technologies in SA education; these include technical problems and the resistance of students to a virtual teacher. Ahmed et al. (2016) evaluated teacher perceptions of the adoption of simulation-based medical education in SA colleges. It has been reported that the virtual environment is an enjoyable, useful evaluation tool for assessing students' learning and can improve students' learning outcomes.

AR technology has been examined at Taif University, SA, in the preparatory year by Alsowat (2016) to investigate its result on students' autonomy, reading comprehension, self-efficacy, and attitudes. The researcher employed the Aurasma application to create AR content and Polyglocam for translating vocabulary from English into Arabic. The results showed that AR enhanced students' reading comprehension, self-efficacy, improved students' autonomy and students had a great attitude towards AR language learning. Also, students had the willingness to use AR in education in the future. Alkhattabi (2017) has reviewed the benefits of using AR applications in a primary school in SA and examined the level of AR acceptance from the teachers' perspective only with a small number of the population. As a result, most of the teachers in the youngest age group (25-35) were positively familiar with AR applications. The female participants had a higher proportion of accepting AR, with 62% more than male participants, so there is a chance of accepting AR technology in classrooms in Saudi society.

These studies (Abou-Elhamd et al., 2010; Adham et al., 2016; Ahmed et al., 2016; Alkhattabi, 2017; Alsowat, 2016; Colbran & Al-Ghreimil, 2013) would have been better if they had concentrated on suggesting a framework to guide the implementation of adopting this kind of technology in the SA higher education system. Recently, the advances in technology make it possible to adopt AR, but as a learning experience, AR needs more exploration than only integrating information about software, hardware and context (Holden, 2014). Wu et al. (2013) argued that applying AR to education should be determined as a concept, rather than any technologies. Therefore, Mitchell (2011) claimed that AR must be defined in such a way to make it be adapted and modified to suit curricular needs and specific context.

However, all the above studies indicate that there are severe limitations to the use of VR/AR, such as technical problems, resources, training, time, personal beliefs, costs, and motivation to integrate this technology into teaching and learning in SA. According to Alkhattabi (2017), several obstacles were found to hinder the adoption of these technologies in SA such as a lack of appropriate ICT infrastructure, ICT competence, resistance to change and the financial support to cover the cost of devices and AR application.

2.6 Challenges Facing the Use of AR in University Education.

Several issues are reported in the literature with the integration of AR in education. From the teachers and designers' perspectives, **controlling and managing the AR experience** is a significant challenge. For instance, some of the institutions' culture and contexts are not well aligned with AR and will take more time to adapt this method (Barroso-Osuna et al., 2019; Clarke-Midura et al., 2011; Klopfer & Squire, 2008). Bower et al. (2016) investigated the most frequently raised issues of adopting wearable technologies such as AR for learning and teaching. These include **technological issues, cost, lack of perceived pedagogical benefit, resistance to change, distraction, and privacy concerns**. The **perception of lecturers** can also be a barrier to the inclusion of AR (Alkhattabi, 2017). Dunleavy and Dede (2014) also found that **cognitive overload, culture and the institute's background** play an important role in the implementation of AR in education. Dunleavy et al. (2009) observed that some educators were overwhelmed by the concept of including AR into the classroom. Another obstacle was that student learning was not controlled, which left learners to learn on their own. The **students' attitudes** and the difficulty of applying AR applications in education are typical constraints (Bacca et al., 2014). Hsiao et al. (2012) reported that when AR is used for the first time, students need to pay much more attention.

Environmental limitations, like infrastructure and AR facilities, have been a frequent barrier to educators when integrating AR and VR into teaching (Alkhattabi, 2017). The findings of the Di Serio et al. (2013) study suggested that factors of **accessibility and usability** are important issues for consideration in future work. System error and usability issues will waste time for students and might take up extra lecture time (Chiang et al., 2014). **Technical problems** are another issue that was repeatedly reported in studies. Using location-based AR in education has a common problem which is caused by GPS error and "low sensitivity in trigger recognition" (Cheng & Tsai, 2013; Chiang et al., 2014). The students became frustrated because of these errors.

The main focus is on the students in the learning process, and the impact of personal, social, emotional, and cognitive factors will influence the learning activities and its outcomes (Akçayır & Akçayır, 2017). Integrating technology to improve the learning efficiency must take into consideration that the teaching methods need to be aligned with the **learners' experiences and characteristics** (Xiao et al., 2016). Based on the Salzman et al. (1999) model, the relation between the 3D virtual learning environment and learning outcomes is mediated by the interaction experience and learners' characteristics. Furthermore, it has been reported that students' achievement is correlated with qualities of individual learners (Education northwest, 2019). Thus, implementing AR technology in the learning environment must fit with the students' characteristics. According to Cheng and Tsai (2013), few studies consider the characteristics of students when engaging with AR in science education (O'Shea et al., 2011; Squire & Klopfer, 2007; Squire & Jan, 2007). Students were divided into three groups by their age in a Squire and Jan (2007) study, and older students were more interactive in AR game tasks, whereas the younger students rejected the AR game's hypothesis. In the O'Shea et al. (2011) study divided students into two groups in designing AR curriculum, males and females. The O'Shea results showed that the group of men communicated more than the group of women in the AR environments.

Hafizul Fahri bin et al. (2016) argued that different learning performances are achieved by male participants based on the learning style that they used. In other words, different learning methods were used among male participants by using AR applications in different forms; some male students learned more effectively using Collaborative Mobile Augmented Reality Learning Application (CoMARLA) than males who used PCs with a similar application. In contrast, no difference between women's learning was identified. In comparison to traditional methods, Albrecht et al. (2013) studied the **emotional and cognitive** impact of AR technology in student learning. The results show that student fatigue was decreased significantly and student vigour slightly increased.

However, despite the scant support from various researchers for the effectiveness of AR, other researchers have stressed its significance in the learning field (Bujak et al., 2013; Chang et al., 2014), classroom environment or as an evaluation tool (Bujak et al., 2013; Chang et al., 2014; Wu et al., 2013). Researchers Ausburn and Ausburn (2010) highlighted that there are a few studies that explore and explain the effect of AR regarding theoretical perspectives and models. Several studies (Hokanson et al., 2008; Patera et al., 2008) also argued that more research on AR is needed to investigate the emotional, social and cognitive dimensions of human experience in the virtual world, rather than just technical issues to facilitate end-user acceptance. Cheng and Tsai (2013, p. 449) suggested that "more research is required to explore learning experience (e.g., motivation or cognitive load) and learner characteristics (e.g., spatial ability or perceived presence) involved in AR." Different factors including emotional, **social and individual beliefs; prior knowledge** and cognition were cited in the literature as critical factors to be examined for their impact on teaching outcomes when technology is integrated when compared to traditional methods.

Creating AR contents was also mentioned as a limitation to adopting AR technology in education (Bacca et al., 2014). Teachers found it difficult to design new learning content. There is some evidence to suggest that teachers need authoring tools to allow them to create interactive 3D content (Chiang et al., 2014; Wojciechowski & Cellary, 2013). Garcia et al. (2010, p. 16) point out: “The main challenges for AR adoption in the teaching context lie in **training** and in the development of methodologies which can help to make visible the potential that this technology holds for teaching and learning.” A lack of students’ essential skills is another learning challenge in AR environments that might prevent the effective adoption of this technology (Barroso-Osuna et al., 2019; Kerawalla et al., 2006). According to Fonseca et al. (2014, p. 435), “Technological innovation, which is intended to improve the student learning process, must be capable of providing support to address difficulties that could arise with the student in the use of and interaction with technological elements. These elements must not obstruct the auto-learning process, which is altered by this technology, and the students must be motivated with the new educational methodology.”

However, with new smart mobile devices, integration and technical issues can be mostly resolved. These devices include more accurate GPS, faster processors, a built-in video camera, and wireless receivers. Using the AR system in mobile devices such as smartphones and tablets make the use of educational AR applications more integrated, reliable, and easy to adopt. Nevertheless, Dunleavy et al. (2009) also indicated that class rules often restrict mobile devices use and other handheld appliances. In the end, lecturers may face problems with leadership and some policymakers who are still unaware of the advantages of incorporating innovative technologies in universities.

2.7 AR Frameworks and Models in Education

In this section, several models will be discussed, and the most important aspects of each will be identified. It discusses the theoretical and conceptualisation of AR in education by AR researchers who have suggested their model and frameworks; however, Table 6 will identify the gap in each model based on the current intensive literature review. It illustrates how several factors are missing in some models and frameworks, and very few have discussed developing an AR framework specifically for educational implementation including personal, social, cultural, cognitive and emotional factors which are essential in developing countries to encourage end-user adoption. Most of the models that have been reviewed for this research focus on AR effectiveness and technical issues.

To produce a holistic framework for developing nations, the framework needs to consider factors that may influence the new technology adoption in education contexts, such as a flexible organisational culture, the pedagogical factors, and individual-related factors (Lin et al., 2012; Maleko Munguatosha et al., 2011).

In this study, a comprehensive approach to developing a hybrid framework was adopted by combining factors of various studies, models and frameworks. At the end of this section, Table 4 demonstrates a summary of considered factors derived from models and frameworks in literature. AR models that are related to the research area are listed below:

2.7.1 AR Integrated Simulation Education (ARISE)

Carlson and Gagnon (2016) developed the ARISE framework that includes factors which examine the relationships between game theory, augmented reality and simulation. The conceptual framework was designed to illustrate the way of combining AR gaming media and situated learning theory. Carlson and Gagnon’s research aims to improve healthcare simulation, learning outcomes, and critical thinking by providing a more engaging and authentic experience (please see Figure 18). The ARISE model includes facilitating methods such as the pedagogical approach which might influence the adoption of AR in the education sector.

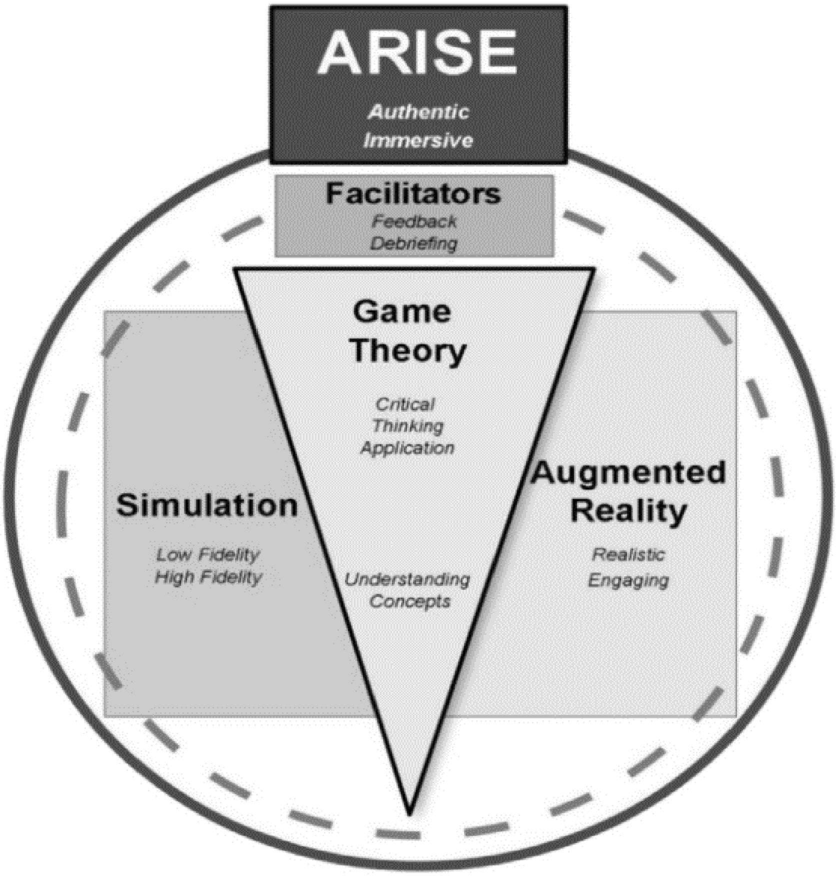


Figure 18: Augmented Reality Integrated Simulation Education (Carlson & Gagnon, 2016)

2.7.2 U-Learning Environment-Based AR Model

Xiao et al. (2016) proposed a model called U-learning environment-based AR that includes three factors, learning place, learners' characteristics, and technological support. Xiao 's model was designed comprehensively to increase learning effect and improve the learning experience (please see Figure 19). The place of learning applies primarily to the location where students perform learning events. This model relies on the technical support requirements as an important factor for implementing AR-based learning system. Additionally, characteristics of the learners, such as cognitive, emotional and social characteristics, were considered as influential factors to integrating AR technology-based learning system.

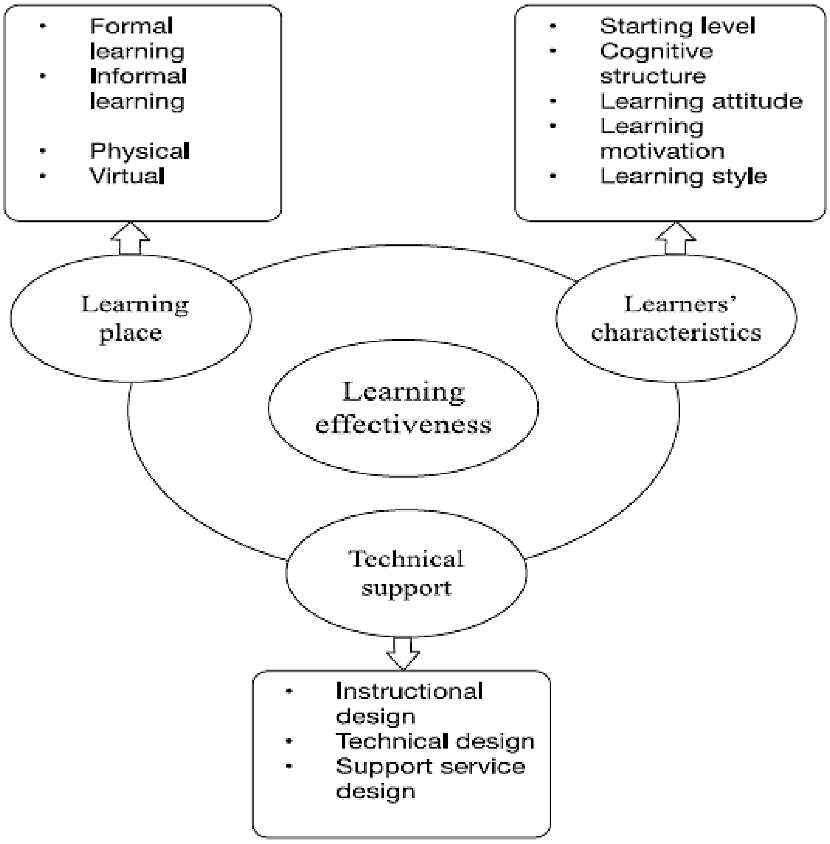


Figure 19: A comprehensive model for the U-learning environment based AR (Xiao et al., 2016)

2.7.3 AR Framework for Mathematics Classes

Bujak et al. (2013) proposed a framework for understanding AR learning experiences for a mathematics class. The framework includes three factors, namely: (1) cognitive, (2) physical, and (3) contextual. Bujak et al.'s framework focuses on psychological factors that can be used as guidelines in AR learning experiences.

Bujak et al. (2013) argued that physical manipulation with AR content allows for natural interactions, thus encouraging the creation of educational concepts of embodied representations, while contextual factors in AR learning environment facilitates meaningful personal experiences. The cognitive considerations were highlighted in a Bujak et al. (2013) study as an important factor in the AR learning experiences because most tasks occur in a computer-based environment, which could contribute to cognitive load, thereby reducing learning ability.

2.7.4 Theories Guiding AR in Science Education

Cheng and Tsai (2013) developed a framework by addressing four theories (mental models, situated cognition, spatial cognition, and social constructivist learning) that are relevant and specific affordances of AR technology in science education. These theories are considered essential components in guiding the adoption of AR in science education. Cheng and Tsai’s framework is considered a good step for researchers to elaborate on the use of AR in educational science. Figure 20 illustrates the Cheng and Tsai framework. According to Cheng and Tsai (2013), spatial cognition is fundamental to a theoretical framework to guide AR research either in the sense of image or location-based settings involving awareness or beliefs of the spatial properties (e.g., scale, shape and position, or direction). Internal-thinking processes, or representations of how an external reality works, may play a role in AR-related learning and are included in the mental model. Situated cognition was considered to be a valuable theoretical viewpoint for founding science education research related to AR, in particular for locational AR. The foundation on which location-based AR activity design is built, is social constructivist learning; thus, it was included in Cheng and Tsai’s framework.

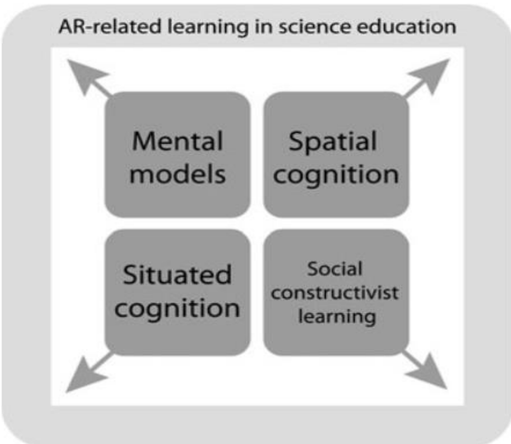


Figure 20: A framework of theories guiding AR research in science education (Cheng & Tsai, 2013)

2.7.5 Eco-Discovery AR-Based Learning System Model (EDALM)

Another model developed by Huang et al. (2016) Eco-Discovery AR-based Learning System Model (EDALM) concentrated on learning outcomes and emotional factors with AR technology. The Huang et al. model includes four stages: abstract conceptualisation, active experimentation, real experience, and reflective observation. The model aims to guide students' learning experiences with AR technology, compared to the human-guidance, via four stages (please see Figure 21). Results show that the traditional guided tour approach allows students to depend on the knowledge of the commentator. The study enables students to explore and study on their own, giving them a greater sense of competence by creating a virtual environment for personal exploring.

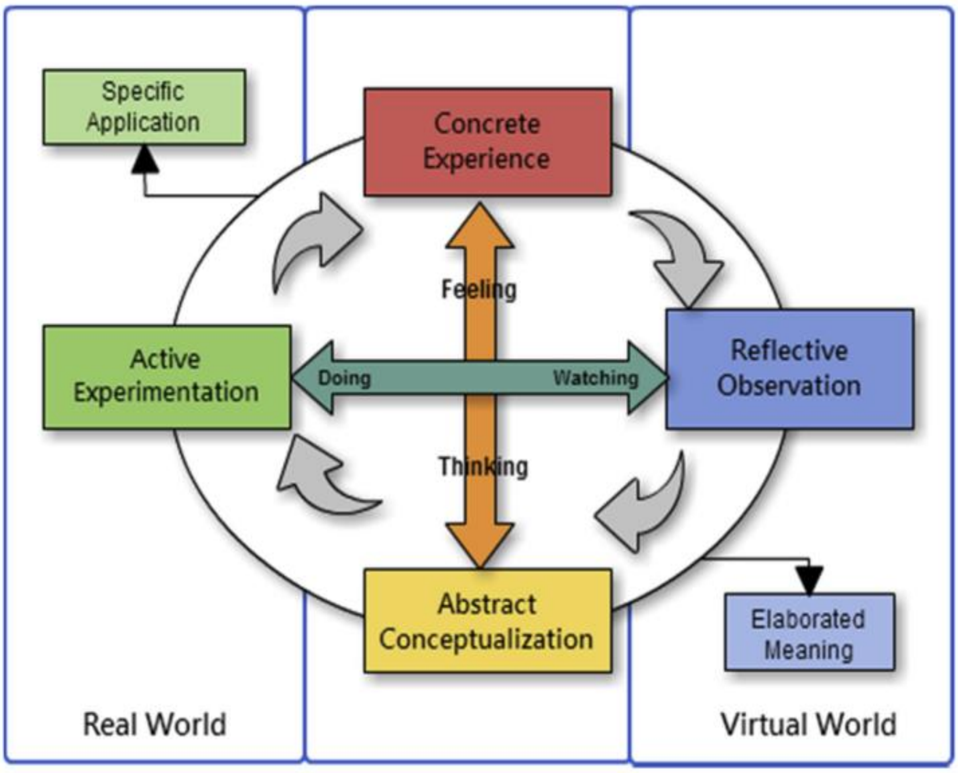


Figure 21: AR-based learning model (EDALM)(Huang et al., 2016)

2.7.6 Education Augmented Reality App (EDAR) Framework

Rauf et al. (2016) proposed an AR conceptual framework to design and develop a mobile educational AR app to enhance the level of students' creative thinking. Their framework depicts the five systematic factors that guide building useful instructional materials (please see Figure 22).

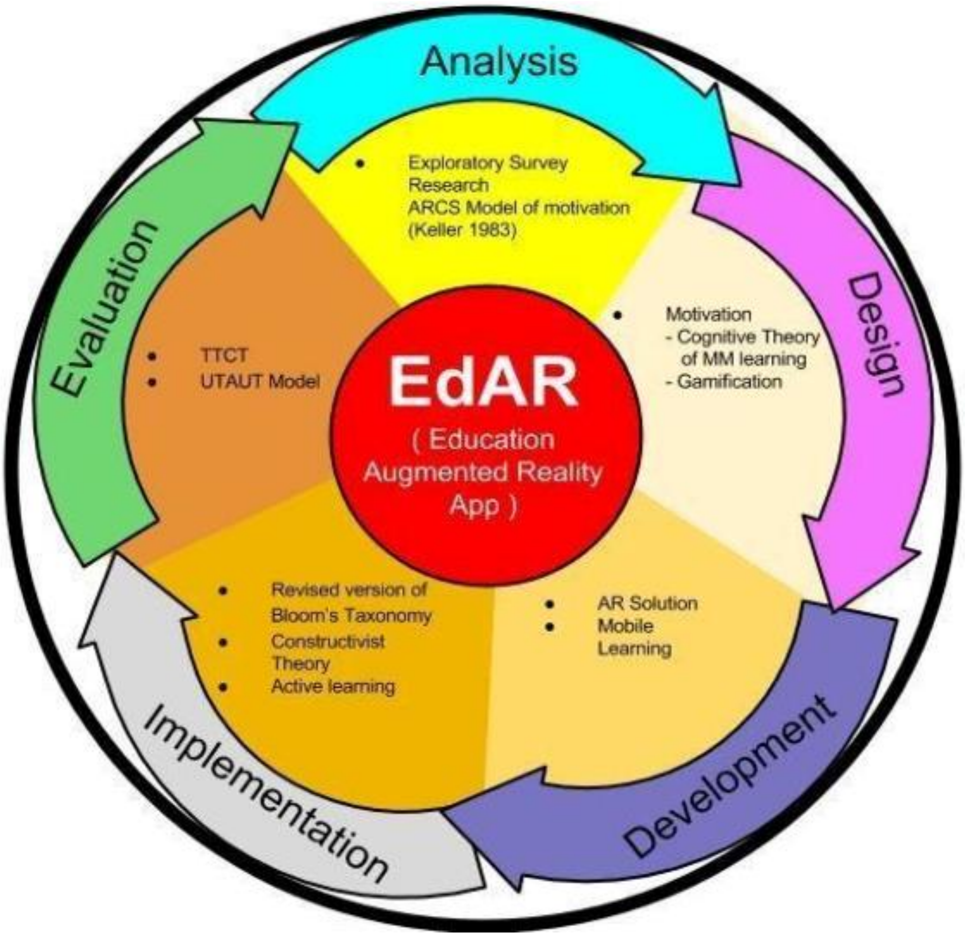


Figure 22: A framework for the design of EDAR (Rauf et al., 2016)

When designing an educational AR app, an instructional design model should be followed, known as the ADDIE model. ADDIE is an abbreviation for five factors: Analysis, Design, Development, Implementation, and Evaluation. EDAR expands the ADDIE model to be aligned with designing and developing educational AR apps. The framework only focuses on establishing a proper development plan for e-learning products. The analysis phase involves the necessary research to determine the topic of the application. The design phase focuses on the human cognitive processes and cognitive theory that need to be considered in the design phase to promote the best learning in educational AR environment. The development stage requires the development of a curriculum based on the specific context of learning. During this process, a clear instructional management plan and content selection are also decided on. The implementation phase relies on the specific context that the learning will be performed in; thus, AR implementation is guided by theories. The last step is the evaluation factor which seeks to assess the quality of the learning to determine whether AR technology has an impact on performance.

2.7.7 The eSTAR Conceptual Model

Another AR model in science education was designed by Gopalan (2016) which described the essential components required to develop an AR application for science education. Gopalan's conceptual model depicted principles and theories that were used as keys to improve AR applications and enhance the existing science textbook. The Gopalan conceptual model includes three design components, namely; design for presentation, design for interaction, and design for information (please see Figure 23); this model focused mainly on design strategies. Many essential models, theories and concepts were used in the eSTAR model such as ARCS: Attention, Relevance, Confidence and Satisfaction, Cognitive Theory of Multimedia Learning (CTML), Intrinsic Motivation Theory and Multimedia Learning Concepts.

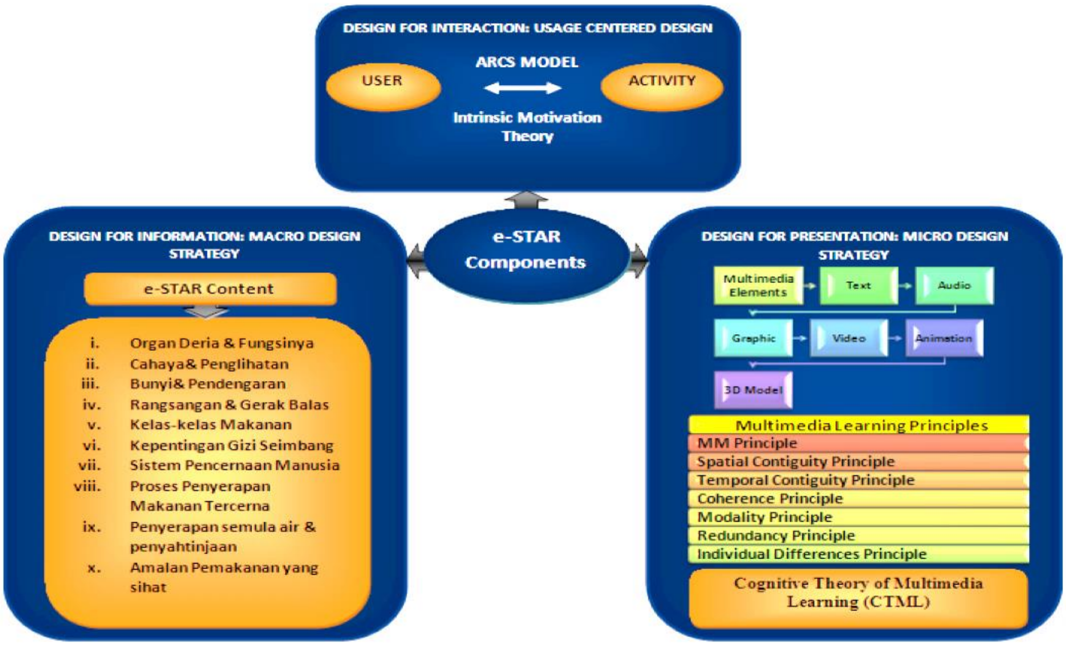


Figure 23: The eSTAR Conceptual Model(Gopalan, 2016)

2.7.8 AR simulations in the learning environment model

Dunleavy et al. (2009) presented an initial model for the development of AR simulations in the learning environment. This framework focused mainly on factors that were considered important in the integration of AR into curriculum design. Dunleavy et al. addressed these factors as issues of AR curricula encountering teachers in AR learning environment. Figure 24 depicts a diagrammatic conceptual framework of the AR learning process. In a Dunleavy et al. (2009) framework design, contextual variables affecting the ease, practicality and effectiveness of the AR simulation design were the subject of the framework.

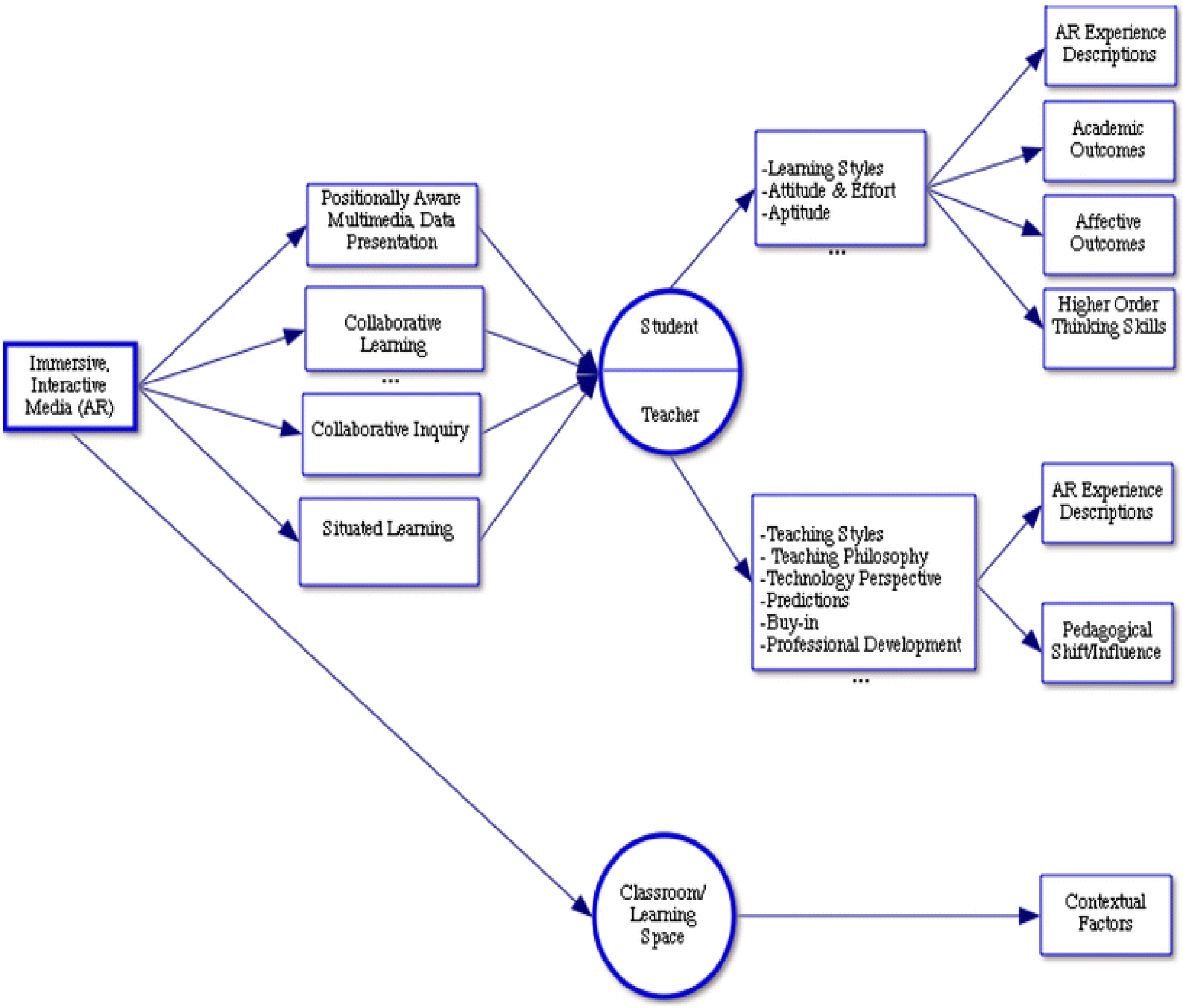


Figure 24: Conceptual Framework (Dunleavy et al., 2009)

2.7.9 Augmented Reality in Computing Education (ARICE) framework

Wang et al. (2013) proposed the Augmented Reality in Computing Education (ARICE) framework to enhance undergraduate students learning outcomes, performance, and retention in computer courses. The ARICE framework involved three aspects: an AR-based learning system, learning materials and exercises, and course delivery as a pilot study. The aim of this framework was to improve computing learning through multiple approaches of AR. The Wang framework is developed to allow students to control the AR content to understand complex topics easily. However, this framework is mainly focused on designing AR interactive games for undergraduate computing education. The AR-based learning system stage provides a platform for presenting learning materials in different formats; training materials and activities use AR technologies best to provide students with a better learning experience and enhances their learning. Finally, an evaluation of the course delivery and students' learning outcomes is conducted.

2.8 Technology Adoption Theories and Models

According to Šumak, Heričko, and Pušnik (2011), as new technology is introduced, different factors affect individual decisions. Exploring these factors is one of the most common issues in technological use in education (King & He, 2006; Oye, Iahad & Rabin, 2011; Park, Lee & Cheong, 2007) to develop a thorough understanding of why and how people embrace technology.

A variety of models have been developed and adapted from different theories and disciplines to simplify the interpretation of why and how universities avoid or accept technologies and to track behaviour in different adoptions (Bates, 2009; Casanovas, 2010; Ma, Andersson & Streith, 2005). The following subsections outline the most popular literature covering technology adoption models. A summary will be given in particular for the Technology Acceptance Model (Davis, 1989; Venkatesh & Davis, 2000), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davids & Davids, 2003), and Diffusion of Innovations Theory, DoI (Rogers, 1983). This research will outline an explaining model that covers the most critical

TAM, UTAUT, and DoI factors as well as provide context for particular factors for accepting AR in SA.

2.8.1 Technology Acceptance Model

Technology acceptance has been defined by Louho, Kallioja and Oittinen (2006) as how people accept, perceive, and adopt technology to be used. Some models are used to guide users to accept or use a particular technology. Studies have been conducted (Balog & Pribeanu, 2010; Wojciechowski & Cellary, 2013) to determine which factors influence users' attitude towards acceptance and implementation of an AR system in learning environments relying on TAM, which was developed and validated by Davis (1989) See Figure 25.

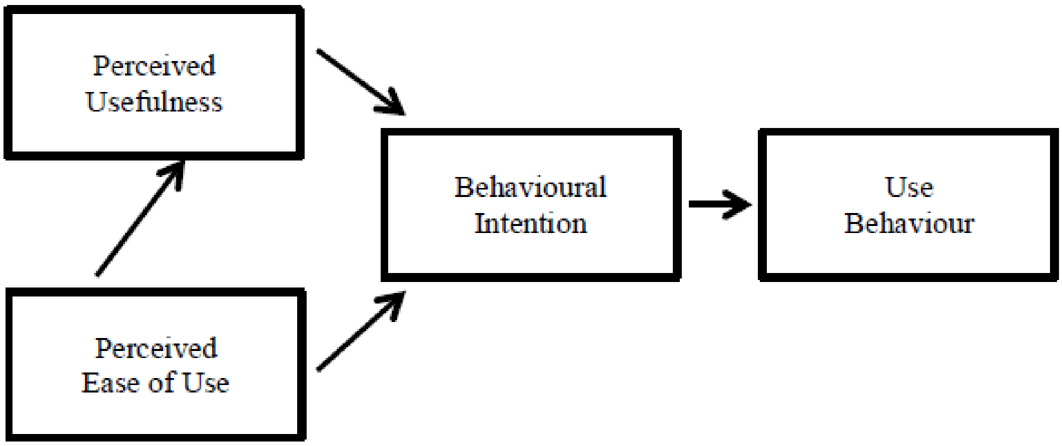


Figure 25: Technology Acceptance Model (Davis, 1989)

According to Wojciechowski and Cellary, (2013, p. 578), the TAM model was criticised by some studies due to "the omission of intrinsic factors that influence computer acceptance." Balog and Pribeanu (2010) found that perceived enjoyment is the key influencing factor of intention to use AR in learning, whereas perceived ease of use has no significant or direct impact. Davis et al. (1992) proposed a revised TAM model by adding perceived enjoyment. Venkatesh et al. (2003) developed the TAM model further by including a range of factors, namely: social influence, effort, expectancy, behavioural intentions and facilitating conditions, which were revealed to influence individuals to accept or reject technologies.

2.8.2 Unified Theory of Acceptance and Use of Technology

Alternatively, Unified Theory of Acceptance and Use of Technology (UTAUT) have been applied by some studies and educational institutions to explore the user's attitudes towards accepting ICT. UTAUT was conveyed by Venkatesh et al. (2003), which comprises four primary factors: Social Influence, Facilitating Conditions, Effort Expectancy and Performance Expectancy (please see Figure 26). All these variables are independent and influence dependent variables such as behavioural and usage to effectively integrate technologies in the education setting. Whereas gender, age and experience have an indirect impact on the dependent variables through the four main factors (Venkatesh et al., 2003).

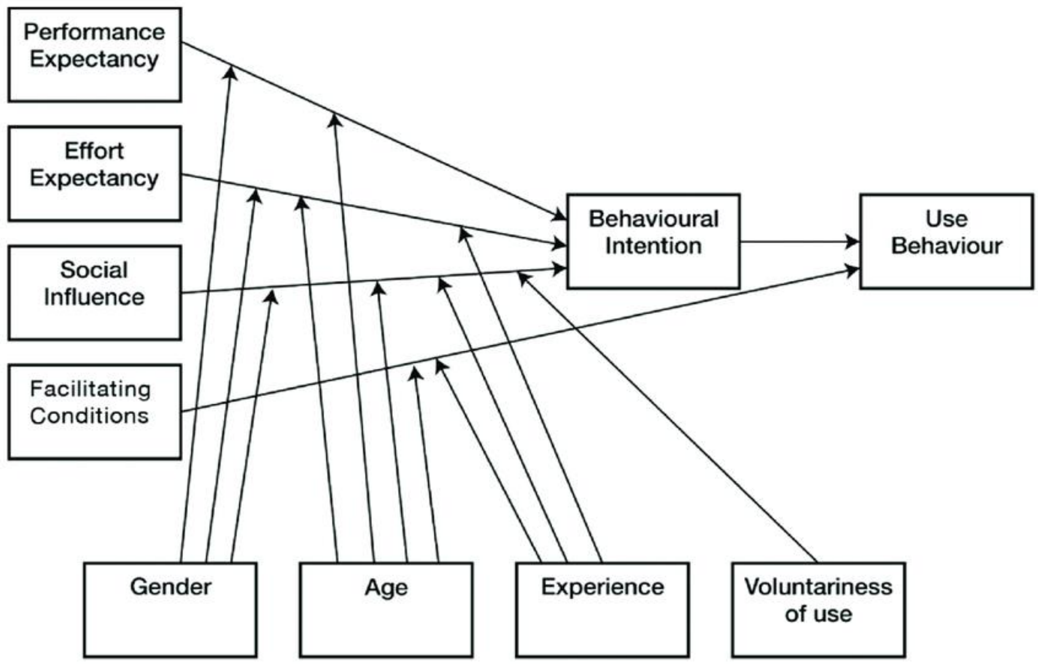


Figure 26: Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)

2.8.3 Diffusion of Innovations Theory

Rogers (1983) presented a detailed theory to explain the acceptance of innovation by individuals and organisations. He argued that the degree of uncertainty about adopting innovation and the strengthening of the social systems affects the technology position. Therefore, the researcher considers that the rate of adoption of innovation depends on five factors, namely: relative advantage, compatibility, complexity, trialability and observability, as seen in Figure 27. The time necessary for innovations to be adopted by a certain percentage of social system members is determined by the rate of adoption (Rogers, 1983). The relative advantage is the perception of staff that technology improves their work performance. Compatibility is identified as "the degree to which an innovation is perceived as being consistent with the existing values, needs, past experiences of potential adapters." (Rogers, 1983, p. 195). Complexity is the goal of an easy to learn and effortless system implemented by organisations. Trialability reveals how potential adopters can quickly test innovation. To facilitate credibility of an invention, the testability is important. Finally, observability ensures that potential adopters can see the effects or advantages of using innovation.

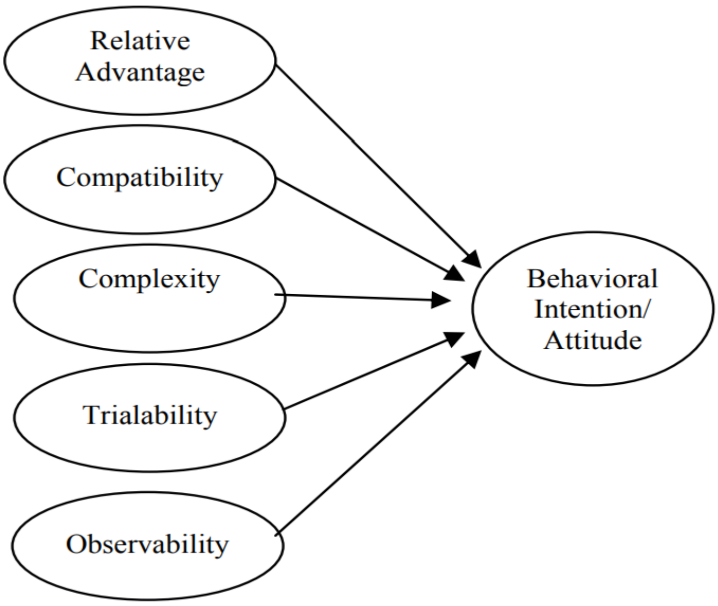


Figure 27: Innovation Diffusion Theory (Rogers, 1983).

This theory has been criticised for providing descriptive information on the adoption process rather than practical information for facilitating it (Lin et al., 2012), the theory of adapting an innovation is considered to be one of the earliest ideas used by researchers.

A summary of AR integration factors selected from the AR models and frameworks discussed in 2.7 and Section 2.8 have been included in Table 4. Since all available models and frameworks cannot be addressed individually, only the most important and popular models/frameworks were discussed in detail. Table 4 summarises some popular and frequently quoted AR models and frameworks that are available in published educational AR research.

Table 4: Summary of considered factors derived from Models and Frameworks in literature

Model/Framework	Considered factors	Authors
ARISE Framework	Pedagogy.	(Carlson & Gagnon, 2016)
U-learning environment-based AR model	Learners' characteristics (emotional and cognitive), technological support, design.	(Xiao et al., 2016)
AR framework for mathematics class	Cognitive dimension, contextual dimension, design, personal relevance.	(Bujak et al., 2013)
Theories guiding AR in science education framework	Pedagogy.	(Cheng & Tsai, 2013)
EDALM Model	Emotional factors.	(Huang et al., 2016)
EDAR framework	Evaluation, design, development, implementation, analysis.	(Rauf et al., 2016)
The eSTAR Conceptual Model	Design, usability.	(Gopalan, 2016)
AR simulations in the learning environment model	Pedagogical factors, contextual factors, attitude, technology perspective, and professional development.	(Dunleavy et al., 2009)
ARICE framework	Design, training, evaluation.	(Wang et al., 2013)
TAM model	Usefulness, ease of use	(Davis,1989)
UTAUT model	Social influences, norms, facilitating condition, willingness	(Venkatesh et al., 2003)
Diffusion of Innovations Theory	Knowledge, relative advantage, trialability, complexity, observability.	(Rogers, 1983)

2.9 An Integrated Approach and the Initial Factors

When adopted models and theories are used individually, they may provide insufficient information for the context under investigation (Straub, 2009). In developing countries and the universities context, the handy model cannot outline factors that might inspire the systems success or failure in integrating AR technology. As a result of a Maleko Munguatosha et al. (2011) study, the work of Venkatesh et al. (2003) needs to be amplified by considering reliable technical and administrative support, adequate budgeting and accountability, self-efficacy, infrastructure, system interactivity, and a flexible organisational culture to adopt new technology in developing countries.

Thus, to gain a comprehensive understanding, researchers adopted an integrated approach by combining constructions of different frameworks and models to build a hybrid model (Park et al. 2008). A comprehensive literature review was carried out regarding AR in higher education environments to identify the factors that must be included in the conceptual framework. The conceptual framework developed for this study was then subjected to further examination and evaluation through stakeholder feedback and includes a range of factors that are believed to be essential to the success of AR integration as an educational tool in SA. These factors are considered a set of practical guidelines and suggestions.

After reviewing each framework and model, the study identified factors found to provide a foundation for successful integration of AR technology. The literature shows that in most educational AR studies that deal so far with the subject, these factors have been considered and discussed in one way or another. Based on the literature review, the following themes were generated:

- Contextual related factors: refer to a range of social, cultural and security factors which may affect the integration of technology.
- Individuals related factors: refer to a range of personal and behavioural factors that might contribute to the success of technology adoption.

- Universities related factors: refer to a range of economic, support and development factors that could be provided by universities to empower the use of technology.
- Technology related factors: refer to a range of design and usability factors that might enable users to use the technology effectively and efficiently.

These themes cluster 11 groups of main factors: sociocultural factors, personal factors, economic factors, technological infrastructure factors, design and usability, support and maintenance, training, pedagogy, evaluation, emotional factors, and cognitive factors (these main factors discussed in section 2.9.1 to 2.9.11) as shown in detail in Table 5. Each of these factors is considered in turn. Table 5 was formed based on these sections 2.4, 2.52.7. The following subsections outline each of these factors to generate the AR framework.

Table 5: Summary of factors considered in this study derived from the literature

Cluster	Potential factors	Source
Contextual-related factors		
Sociocultural factors	• Religion • Ethics and privacy • Culture • Normative beliefs	(Alkhattabi, 2017; Dalim et al., 2017; Dunleavy & Dede, 2014; Lee et al., 2015; Martins et al., 2015)
Individuals-related factors		
Personal factors	• Age • Gender • Perception of technology • Attitude • Willingness or readiness	(Ahmad Fauzi et al., 2019; Alkhattabi, 2017; Alsadoon & Alhussain, 2019; Chin et al., 2016; Dalim et al., 2017; Ibáñez & Delgado-Kloos, 2018; Lee et al., 2015)
Emotional factors	• Pleasing • Engaging • Attractive • Motivating • Fun	(Albrecht et al., 2013; Huang & Liao, 2015; Lee et al., 2015; Rauschnabel et al., 2017)

Cluster	Potential factors	Source
Cognitive factors	• Cognitive load • Prior knowledge • Spatial Ability	(Akçayır & Akçayır, 2017; Chin et al., 2016; Dunleavy & Dede, 2014; Ibáñez & Delgado-Kloos, 2018)
Universities related factors		
Economic factors	• Budget • Financial support	(Alkhattabi, 2017; Almenara & Osuna, 2016; Alsadoon & Alhussain, 2019; Di Serio et al., 2013; Wang et al., 2018)
Technological infrastructure	• Hardware • Software • Internet connectivity	(Akçayır & Akçayır, 2017; Alkhattabi, 2017; Alsadoon & Alhussain, 2018; Bazzaza et al., 2014; Dunleavy & Dede, 2014; Martins et al., 2015; Wang et al., 2018)
Support and maintenance	• Technical support • Institutional support	(Alsadoon & Alhussain, 2018; Dalim et al., 2017; Dunleavy & Dede, 2014; Martins et al., 2015; Wang et al., 2018)
Training	• Professional training and development.	(Akçayır et al., 2016; Ibáñez & Delgado-Kloos, 2018; Kamarainen et al., 2013; Kutbi & Hashim, 2017; Wang, 2012)
Evaluation	• System efficiency improvement. • Assessment technology effectiveness.	(AlNajdi et al., 2018; Alsadoon & Alhussain, 2019; Dalim et al., 2017; Ibáñez & Delgado-Kloos, 2018; Ibáñez et al., 2014)
Pedagogy	• Theories • Practices	(Champney et al., 2015; Mabel et al., 2006; Saltan & Arslan, 2017; Wang et al., 2017)
Technology-related factors		
Design and Usability	• Easy to use • Easy to evaluate • Safe to use • Enjoyable • Satisfying	(Albrecht et al., 2013; Bazzaza et al., 2014; Dalim et al., 2017; Ibáñez & Delgado-Kloos, 2018; Lee et al., 2015; Rasimah et al., 2011; Sumadio & Rambli, 2010; Wang et al., 2018)

2.9.1 Sociocultural Factor

Sociocultural factors are related to the practices, beliefs, religion and customs within cultures and societies that influence the decisions, behaviours and feelings of its people. Scheel and Branch (1993, p. 7) comprehensibly defined culture as:

"...the patterns of behaviour and thinking by which members of groups recognise and interact with one another. These patterns are shaped by a group's values, norms, traditions, beliefs, and artefacts. Culture is the manifestation of a group's adaptation to its environment, which includes other cultural groups and as such, is continually changing. Culture is interpreted very broadly here so as to encompass the patterns shaped by ethnicity, religion, socio-economic status, geography, profession, ideology, gender, and lifestyle. Individuals are members of more than one culture, and they embody a subset rather than the totality of a culture's identifiable characteristics."

The restrictions of religious and cultural beliefs and practices in SAn society cannot support gender-desegregation (Onsman, 2011). Alturise and Alojaiman (2013, p. 46) indicated that "the strict application of Islamic law has led to its education system being segregated according to gender, which has far-reaching implications for the educational environment which puts it at odds with the open-access culture practised in many other countries." Our learning experiences and social realities are mostly shaped by culture. SA culture and religion not only shape people's attitudes, behaviour and practices but also construct their lives. Thus, adopting new technologies in SA culture is considered a significant challenge in the development of learning systems.

Culture can influence learning and how it is learned (Munro, 2012). In social terms, culture is the sharing of attitudes, values and beliefs between society or communities. The social impact factor in the UTAUT includes a perception of others, the subjective culture of its benchmark category and certain interpersonal agreements between the participant and other individuals (Venkatesh et al., 2003). The social factor indicates that an AR user in universities would be sensitive to the views of others not on their university management and would, therefore, make decisions that are compliant with social standards around them.

Based on previous research (Alam et al., 2011; Dalim et al., 2017; Erumban & De Jong, 2006), the sociocultural environment impacts on innovation diffusion in different cultures due to the country's differences in cultural characteristics, demographic, geographic, and socio-economic situation. However, Information Systems (IS) researchers have received little attention from cultural influence on technology outcomes (Straub et al., 2002). Furthermore, the institutions' context plays a role in using technology (Martins et al., 2015). Windschitl and Sahl (2002, p. 165) stated that "The ways in which those teachers eventually integrated computers into classroom instruction were powerfully mediated by their interrelated belief systems about learners in their school, about what constituted 'good teaching' in the context of the institutional culture, and about the role of technology in students' lives."

According to Lee et al. (2015), cultural differences may impact AR acceptance. Changes must continuously occur in any organisation to increase productivity, and traditional learning methods need to be enhanced with modern technology to meet the new generation's requirements and enhance higher education learning outcomes. The beneficial use of AR and its integration strategies in education need to be identified to stakeholders to solve the sociocultural issues. Also, ethics and privacy factors are another concern in adopting AR technology. According to Neely (2019), AR technologies raise several ethical concerns regarding interfering with public and private spaces. Therefore, careful consideration of the potential social benefits and threats that specific types of AR would possibly entail.

As this study investigates AR adoption in SA, it would be beneficial to understand the SAn culture. Therefore, social, ethics, cultures and beliefs may also require a different learning approach, such as new technology.

2.9.2 Personal Factors

Personal characteristics such as gender, age, and educational level can influence perceptions and attitudes towards using technology for educational purposes (Schiller, 2003). A possible explanation for this might be that the adoption and integration of technology into teaching will be influenced by personal characteristics (Buabeng-Andoh, 2012). According to Venkatesh and Morris's (2000) study, age and gender differences have a substantial impact on the decisions to adopt new technology in the workplace. Moreover, Salzman, Dede et al. (1999) indicated that the failure or success of a virtual learning environment could be determined by the following features: learner characteristics, the interaction experience and more informed design, the ideas to be learned, and the learning experience. Mikropoulos and Natsis (2011) believe that individual factors such as age, gender, and computer experience need to be examined in a virtual environment in terms of the learning outcomes. Future research is required to examine how the learning environment of AR can be utilised by more diverse populations of students (Cheng & Tsai, 2013; Zydney & Warner, 2016). Also, the majority of studies examined did not take into account learning features such as gender, age difference, prior knowledge, or skills (Ibáñez & Delgado-Kloos, 2018).

Furthermore, personal perception and attitude have key roles in adopting a specific technology (Kim et al., 2009). Kim et al. (2009, p. 68) stated that “a user who strongly holds a favourable attitude towards using a certain technology may adopt and continuously use the technology, but a user who weakly holds a favourable attitude towards using the technology may be easily persuaded to change that attitude if others point out faults or weakness of the technology, and thus stop the adoption or continued use of the technology.” A positive attitude towards new educational technologies must be developed by teachers and lecturers to implement technology successfully in their teaching process and feel happy using them as instructional tools (Rakes & Casey, 2002).

According to Barroso-Osuna et al. (2019), positive attitudes towards technology use such as AR have long been recognised as an essential element for effective use of these technologies in education. The TAM, which was initially proposed by Davis, Bagozzi, and Warshaw (1989) hypothesised that the intention to use the technology, is determined by behaviour. Whereas the attitude towards technology determines the intention to use the technology. Attitudes towards using the system are hypothesised to mediate the effect of perceived usefulness and perceived ease of use on behavioural intention. Fred Davis (1989, p. 320) defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance." Rogers (2000) suggested that adopting new technology should ascertain attitudes towards technology by involving some strategies to address the “fear factor.” Attitude towards technology has been identified as a significant contributing factor in the literature (Buckenmeyer, 2010; Rogers, 2000) and as a strong predictor of successful technology adoption and use in education.

Furthermore, understanding lecturers and students’ perceptions of AR technology promotes the most beneficial use of this technology in the university environment.

New technology adoption is often a long and challenging process that can be clarified by the concept of innovations in Rogers (1983). This theory attempts to clarify how and why new ideas are spread throughout society. According to Rogers (1983), five variables of the users' perceptions including relative advantage, observability compatibility, trialability, and complexity, are the main characteristics of an innovation that influences its acceptance or rejection. Many studies have revealed that educators' perceptions about the positive impact of technology, such as the educational benefits of technology and pedagogical values, are essential and are positively correlated with the employment of technology in education (Badia et al., 2014; Inan & Lowther, 2010). Alfalah (2018) found that students and teaching staff perceptions are one of the factors influencing VR incorporation in higher education institutions. Moreover, previous studies related to education technology integration in various regions have reported that there is a strong correlation between the belief of the usefulness of these technologies and the intention to use them (Chen & Tseng, 2012; Ottenbreit-Leftwich et al., 2010), the perceptions of users in previous studies were identified as an essential factor for the success or failure of technological integration in education.

Also, successful technology integration requires a willingness to embrace change. Technology willingness or readiness refers to "people's propensity to embrace and use new technologies to accomplish goals in home life and at work" (Parasuraman, 2000, p. 308). Based on a technology readiness definition, AR readiness in the teaching and learning process can be defined as the propensity to embrace and use AR technologies for accomplishing goals in learning. It is related to the ability of the universities as a whole to apply new technology, educate and train users to employ it effectively and make it available for constant use (Twigg, 2000). Machado and Chung (2015) examined the factors that influence technology integration in education from the school principal's perspective using a survey and an interview. The results illustrated that professional development and perceived teacher willingness were the most substantial obstacles. Teachers and students must be willing and able to use technology effectively in their teaching and learning to realise the benefits that it can offer (Luan et al., 2005). These factors need to be considered in the AR learning environment, especially in this research.

2.9.3 Economic Factors

To embrace new technologies in the higher education sector, it is necessary to understand the economic conditions for institutions (Shohel & Kirkwood, 2012). Adopting AR tools into higher education may require a large budget. Equipment needs to be acquired to leverage AR for quickly accessing educational content in classrooms such as cameras, projectors and computers. The cost of providing all these AR requirements can be expensive (Barroso-Osuna et al., 2019). A table of estimated costs is provided on page 308.

Furthermore, additional costs are needed to keep this technology running and up-to-date. Apart from the initial cost of technology, there is also a cost of training teachers in the use of technology and educational content. Financial support was suggested in the literature to be considered for technology adoption (Barroso-Osuna et al., 2019; Bonsu et al., 2013; Buabeng-Andoh, 2012). According to Lee (2012), adoption of AR systems in the education sector is low due to the lack of government financial support, and they concluded that more studies are needed to overcome this issue and draw government and organisation attention towards financially supporting AR use in education and training. Greenwood et al. (2010) argued that dedicated financial and administrative support is required for any innovation to take off.

2.9.4 Technological Infrastructure

To develop, deliver, monitor, test, control or support IT services in universities, a collection of hardware, software, networks and facilities are required to operate and manage an IT environment (Alsadoon & Alhussain, 2019). Technology infrastructure is a complex issue, and universities' decision-makers need to realise the importance of technology infrastructure as a means of improving teaching and enhancing learning outcomes. Altameem (2013) stated that some of the universities in SA still have a weak infrastructure, which makes people reluctant to use the available services and systems.

However, due to poor organisation, technology is not always used efficiently (Althonayan & Papazafeiropoulou, 2011). According to Alturise et al. (2016), ICT infrastructure issues prevent teachers and students from utilising and integrating new technologies into university courses. Therefore, an efficient technological infrastructure will encourage the use of new technologies such as AR in the education sector. Implementing AR technology at university levels requires technologically complex hardware, but with modern devices and learning environments, it becomes affordable (Singh & Singh, 2013). Following the technological development of AR, the maturity phase will soon be introduced. Infrastructure requirements have been a focal subject since 2001 (Jeong & Yoon, 2017); many software companies and camera manufacturers have dominated the recent evolution of AR.

2.9.5 Design and Usability

Usability is about ensuring users that the system is competent, efficient, safe to use, easy to use and evaluate, enjoyable, and satisfying (Issa & Isaias, 2015). Jakob Nielsen (2003, p. 68) defines usability as "a quality attribute that assesses how easy user interfaces are to use." To ensure usability, the user should participate in the development process to prevent future user frustration and error and meet the users' requirements. According to Dey et al. (2018) different AR usability principles and user experience issues need to be taken into consideration to be widely accepted by end-users and to ensure that the user learns the system and can easily use it. AR systems in education have been reported in several studies (Chiang et al., 2014; Kaufmann & Dünser, 2007; Muñoz-Cristóbal et al., 2015), as more complicated than physical or desktop-based alternatives.

On the other hand, interestingly, many AR systems that were found to be liked by users and accessible were used more than the alternatives. Introducing technologies within the learning environment must be designed to be user-friendly to be well accepted (Rasimah et al. 2011; Sumadio & Rambli 2010). Cheng and Tsai (2013) reported that usability problems (i.e. cognitive issues, frustration) must be addressed in AR technology, as the students may encounter difficulties and reject the use of AR without well-designed interfaces. Rasimah et al. (2011) claim that more attention needs to be paid to the usability of the AR applications to be successfully introduced to the users. AR systems need to be designed in such a way that is satisfying, enjoyable, and acceptable to the authorised entity.

2.9.6 Training

Providing training can be considered one of the factors that encourages the use of new emerging technologies. Training (as an external factor) in the TAM model is necessary because of its impact on both the perceived ease of use and the perceived benefits of a system, which may affect the intention to use the system. In other words, the acceptance of technology by users is fundamentally affected by training (Davis, 1989; Renny et al., 2013). This is because attitudes towards technology are predicted by both the 'usefulness' and 'easy to use' aspects of technology.

Training in the use of technologies should be introduced in universities when they intend to integrate technology in an educational environment. The main goal of training is to introduce teachers and students to different appropriate technologies that shift the traditional learning method to an effective learning method that will enhance learning outcomes. To achieve this goal, adequate training is needed to encourage both teachers and students to use the technology. Follow-up training has been acknowledged as a significant factor in integrating AR technology in the classroom (Barroso-Osuna et al., 2019; Dwyer et al., 1994). The integration of ICT in learning and teaching in education environments in SA has been examined by Bingimlas (2009), who indicated that teachers are confident and competent in using technology in the classroom, but practical training in the use of available ICT is missing. Christensen (2002) argued that to increase teachers' confidence and competency level to adopt the technology, a training facility should be available. Finally, for new technologies to be used appropriately in education, proper in-service training is essential.

2.9.7 Pedagogy

The focus on technical rather than pedagogical aspects minimises the impact on the learning outcomes of ICT initiatives (Bernard et al., 2014). Selecting appropriate pedagogy is essential when utilising technologies for learning purposes (Barroso-Osuna et al., 2019). Pedagogical aspects were found to be essential in influencing the decision of education policies, resources and operations by faculties (Dabbagh, 2000). Passey and Higgins (2011, p. 329) detailed that: "A learning platform is not a piece of computer software designed to improve teaching and learning in some particular aspect of the curriculum or in support of a particular pedagogy. Instead, it is a collection of tools brought together to improve a range of aspects of the workings of a school, university or other educational organisation." Educating students on all topics using one learning style is challenging. To understand and benefit from AR learning environments, pedagogical theories need to be considered (Wang et al., 2018). Pedagogical theories can assist with various types of students with different learning styles.

2.9.8 Maintenance and Support

After careful planning and hard work, the integrated technologies in organisations need to be updated to ensure that they are running flawlessly. Maintenance and support are required after implementing new technologies to keep the system running efficiently and effectively. The National Center for Education, (1997, p. 27) stated that "support services, training, and certification must be ongoing to ensure successful post-implementation use of technology." Maintenance is the correction of errors that appear after release and not evident during the development of the system (Dix et al., 1998). Maintenance is about updating, replacing, diagnosing, repairing, and protecting the organisation's system, while support is a process that helps and keeps users working and using the system properly. Al-Alwani (2005) found that there was no instructional support for integrating IT into education in SA. Another study (Barroso-Osuna et al., 2019) indicated that for successful implementation of AR in university education, institutional support is essential.

Thus, the implementation of new technologies like AR in universities should be supported and maintained by universities or outsourced to contractors to achieve the desired goals. Furthermore, technical expertise and domain expertise are required to create AR educational content (MacIntyre et al., 2003). It has been suggested that in addition to the level of support, well-planned and ongoing professional development are essential to make the successful implementation of new emerging technology in education.

2.9.9 Evaluation

Evaluating the system is a critical phase to achieve the goal of developing or updating system. When the system is introduced or released, an evaluation should be conducted. Preece and Keller (1989) explain the reasons for evaluation: (1) to observe how the user employs the new technology in the workplace to collect further information that can help developers or designers to improve the technology to match the user's needs and context; (2) to ensure that the goal of the technology is achieved and matches the user's needs; (3) to identify which is the best by comparing and contrasting the new smart technology design in line; and finally (4) to ensure it conforms to a standard.

Issa and Isaias (2015, p. 84) emphasised the importance of evaluation and testing as "these aspects will assist users and designers in identifying the problems and identifying some solutions to prevent them in future." Regular evaluation is an essential factor to identify the outcomes of AR use in education to improve its efficiency. According to Herpich et al. (2019), evaluation methodologies must be applied to allow AR contributions to be potentiated when using them in educational contexts.

2.9.10 Emotional Factor

The learning process in higher education can be affected by emotion. Motivated students can confidently demonstrate their level of knowledge. Emotion plays a significant role in both teacher and learner behaviours and plays a significant role in learner motivation and self-esteem (Dirkx, 2008). Jarvis (2005, p.102) explained the relationship between emotion and learner as "emotions could have a considerable effect on the way we think, on motivation and beliefs, attitudes, and values." The study of Pekrun et al. (2002) also confirmed the importance of 'achievement emotion', which is vital to the academic performance of students as well as in all academic settings. Several studies (Dalgarno & Lee, 2010; Kye & Kim, 2008) also concluded that the positive impact of the virtual learning environment on emotions would enhance students' cognitive processes and performance. According to the findings of previous studies (Huang et al., 2016; Park et al., 2015; Plass et al., 2014), to integrate cognitive and affective processes, emotional design research is needed. Straub (2009,

p. 625) concludes: "successfully facilitating technology adoption must address cognitive, emotional, and contextual concerns."

2.9.11 Cognitive factor

The thinking processes of students can be supported, guided, and extended when computer technology is involved in the learning process (Derry & Lajoie, 1993). However, technology may pose additional processing demands and increase students' cognitive load, which prevents them from learning (Cheng & Tsai, 2013; Dunleavy et al., 2009). Moos (2013) found that using multimedia, including several sights and sounds when students are doing assignments, causes cognitive overload. Kalyuga and Liu (2015) suggested that the cognitive characteristics of learners should be considered to guarantee the instructional effectiveness of any technological innovation; otherwise, students will become frustrated. Wu et al. (2018) note that learning in an AR environment has caused an issue related to students' cognitive overload when interacting in both the real-world and digital-world information.

Moreover, the level of students' prior knowledge can influence student learning outcomes in virtual learning, and it should be considered in AR learning. Cai et al. (2016, p. 3) indicated that "With sufficient prior knowledge, whether we use abstract objects in teaching causes no impact on learning; this suggests that the influence of technological innovation must be closely correlated with the students' prior knowledge. This also leads to the question of what influence an AR-based natural interface learning environment has for students with different levels of prior knowledge." Therefore, better consideration should be given to cognitive barriers to using AR in university before integration, could improve the efficiency and effectiveness of implementing these technologies.

2.10 The Research Gaps and Conceptual Framework

As indicated in section 2.7, several models have been developed to adopt AR in education and provide several factors of AR implementation. So most of these models and frameworks, which have been discussed in 2.7, have focused on the development, AR effectiveness, acceptance level, technical issues, usability and initial implementation of AR. The pedagogical aspect and certain technology dimensions were not addressed together by any model. These models and frameworks cannot be applied and used in university settings in SA, as there are specific differences in existing conceptualisations of AR in higher education that, in many ways, impedes their adaptation in developing countries like SA; however, very few have discussed the critical factors which might support the integration of AR into higher education especially in developing countries such as personal, social, cultural, and emotional factors (Al-Alwani, 2005; Al-Jarf, 2005; Almalki et al., 2013; Amoudi & Sulaymani, 2014; Adham, Lundqvist & Parslow, 2016). A common set of AR adoption factors in higher education is lacking, which could help to encourage AR adoption at universities in SA. Furthermore, a holistic AR model or framework in higher education, particularly in the developing countries, has not been empirically validated or tested.

After comparing these studies with the identified factors, discussed in section 2.9, some of the factors are missing in some models, and none will be suitable and appropriate for higher education in SA.

Table 6 shows the existing AR models and frameworks that are missing some identified common factors (please see Table 5) for SA universities.

Table 6: Research gap analysis table ('√' means this factor is addressed in this model or framework)

		Pedagogy		Sociocultural factors				Personal Factors (PF)					Cognitive Factors (CF)			Universities and Technology-related factors						Emotional factors				
Frameworks/ Models	**Authors**	Theories	Practices	Religion	Ethics and privacy	Culture	Normative beliefs	Age	Gender	Perception	Attitude	Willingness	Cognitive load	Prior knowledge	Spatial Ability	Technological infrastructure	Design & Usability	Support & maintenance	Training	Evaluation	Economic	Pleasing	Engaging	Attractive	Motivating	Fun
ARISE Framework	(Carlson & Gagnon, 2016)	√	√										√										√			
U-learning environment-based AR model	(Xiao et al., 2016)							√	√		√		√				√	√							√	
A framework for AR for mathematics	(Bujak et al., 2013)										√		√	√	√		√								√	
A framework of theories guiding AR research in science education	(Cheng & Tsai, 2013)	√	√																				√			

		Pedagogy		Sociocultural factors				Personal Factors (PF)					Cognitive Factors (CF)			Universities and Technology-related factors						Emotional factors				
Frameworks/ Models	**Authors**	Theories	Practices	Religion	Ethics and privacy	Culture	Normative beliefs	Age	Gender	Perception	Attitude	Willingness	Cognitive load	Prior knowledge	Spatial Ability	Technological infrastructure	Design & Usability	Support & maintenance	Training	Evaluation	Economic	Pleasing	Engaging	Attractive	Motivating	Fun
EDALM	(Huang et al., 2016)												√										√			
EDAR framework	(Rauf et al., 2016)																√	√		√						
The eSTAR Conceptual Model	(Gopalan, 2016)																√									
AR simulations in the learning environment model	(Dunleavy et al., 2009)	√	√							√	√					√	√	√	√							
ARICE framework	(Wang et al., 2013)																√		√	√						
TAM model	(Davis,1989)									√	√	√														
UTAUT model	(Venkatesh et al., 2003)			√	√	√	√	√	√							√	√	√	√		√					
Diffusion Theory model	(Rogers, 1983)								√			√		√			√			√						

To the best of this researcher's knowledge, none of the studies reviewed thus far has addressed all of these dimensions comprehensively in a conceptual framework. According to Bower et al. (2014, p. 7) "without such frameworks, the application of technology within the classroom is often superficial and unproductive." Also, several calls in the literature have highlighted the need for a conceptual framework regarding the implementation of technologies such as AR systems (Ertmer et al., 2012; Rasimah et al., 2011). Consequently, this research will attempt to address the gap in the literature by developing a theoretical framework for using AR in higher education by embedding these dimensions: emotional factors (EF), personal factors (PS), sociocultural factor (SF), pedagogy, economic factor, cognitive factors (CF), evaluation, usability, training, infrastructure, and support and maintenance that may best suit the Saudi unique cultural, social and technological needs.

Figure 28 demonstrates the conceptual framework that includes all these factors, which are all independent factors. The conceptual framework classifies the relevant factors in AR higher education system development and integration in SA. Until recently, no study has been conducted on identifying factors or developing a framework for the implementation of AR in SAn universities. The initial framework will be examined and assessed by several stakeholders in Saudi universities.

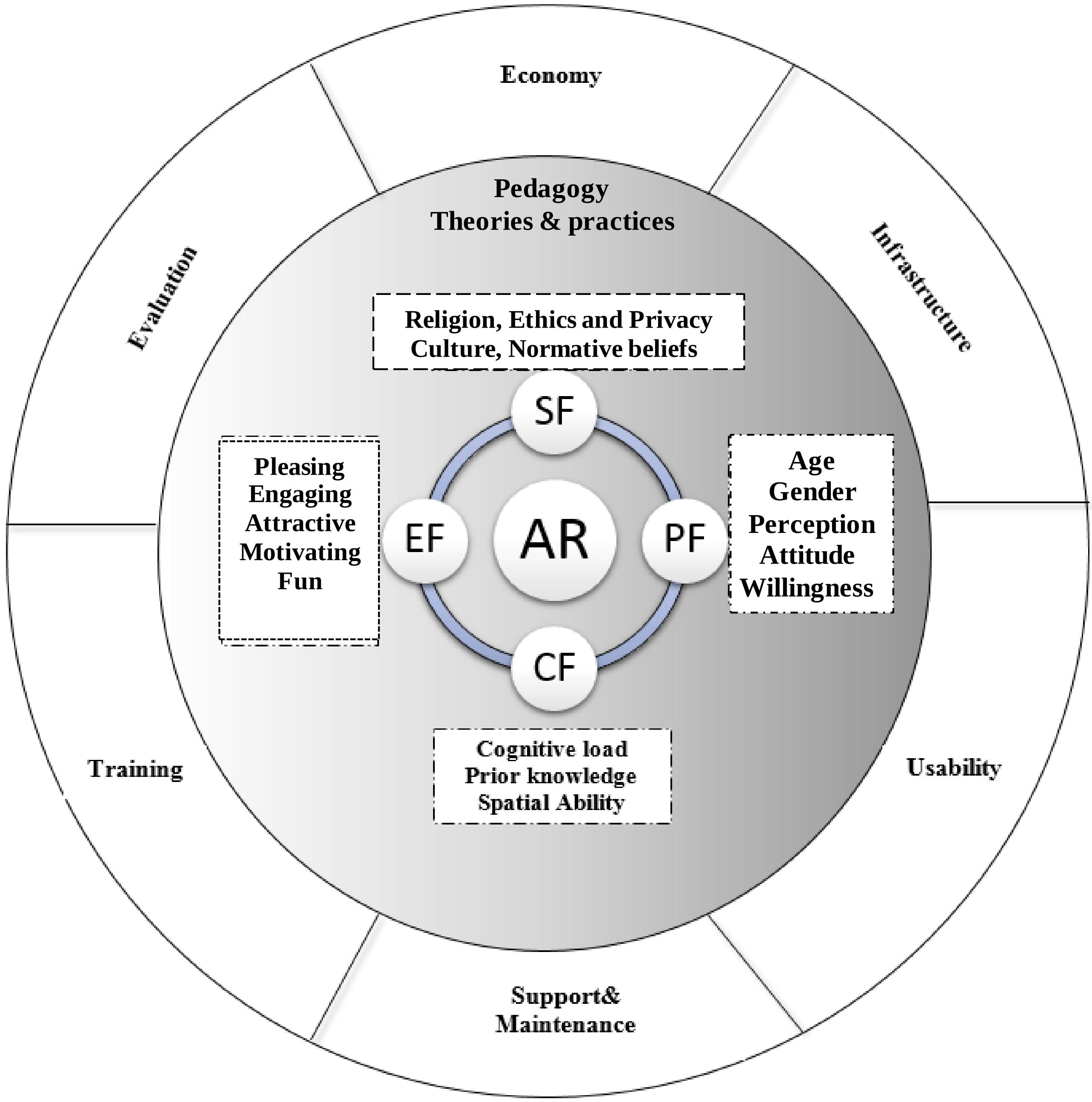


Figure 28: Initial Augmented Reality Framework for Universities in Saudi Arabia (prepared by the author)

2.11 Conclusion

The current literature on AR in education is discussed in detail in this section to frame this research. It firstly outlined the background of the use of AR technology and illustrated several popular fields adopting AR technology. This included an examination of current global studies into AR implementation in education and identifying the major research trends of AR integration and use in higher educations. A thorough assessment of the factors contributing to the inclusion of AR technology into higher education has also given substantial proof of the need for further research to confirm each factor, particularly for universities in SA.

It is also included the analysis of several AR models and frameworks in education from literature. It was found that none was suitable or appropriate for higher education in SA, and none captured all the factors that emerged from this review. An AR framework would bridge this gap to better guide Saudi universities in their development and integration of innovative technologies in the learning process.

Thus, many factors that emerged from the literature have been combined to create the conceptual AR framework. These findings from the literature review will be evaluated and assessed with quantitative and qualitative data collection, and refinement of the framework will be conducted in the chapters that follow.

The research approach had to be defined before commencing the data collection. Chapter three (3) explains the decisions made.

Chapter 3. Research methodology

3.1 Introduction

In Chapter 2, different sources were reviewed related to educational AR literature including conference proceedings, books, journal articles, published reports on AR in education, and studies published in Social Sciences Citation to cover all AR models, frameworks and essential factors of educational AR. Details on the scope of literature research and criteria of the selection were provided. It also examined, in detail, the educational use of AR as well as the essential factors for AR adoption in universities of SA. Finally, the research gaps were highlighted at the end of Chapter 2.

This chapter aims to present and address the selection of the research methodology for this study. In Chapter 2, the research gap for this study was identified that no empirically validated frameworks with no or limited data evidence from participants are available for SA universities; therefore, the research study objective aims to develop, understand, and evaluate the AR framework. Ideally, a mixed-method approach is needed for these processes to shape and evaluate AR framework. The researcher developed a conceptual framework to graphically clarify key factors to be studied, as seen in Figure 28.

The design of the mixed-method approach is explained in this chapter, and the reasons for following this approach are justified. This is followed by clarifications of the research stages. For each sequential phase, data collection, sample selection and data analysis are clarified. Finally, the researcher addresses issues of validity, reliability, credibility, transferability, confirmability, and research ethics as relevant to this study. The 'how' and 'why' of this study is also addressed in this chapter.

3.2 Purpose of Research

As stated earlier, this study seeks to develop, understand and evaluate an AR framework for universities in SA. Most importantly, it reflects on how it may be best integrated for education purposes in SA, with highlighting the necessary conditions and factors such as social, cultural, pedagogy, infrastructural, technology usefulness, usability experiences, government support, and students and staff reaction that either support or limit the process. Further, this study aims to create an integrated framework that includes all factors related to the adoption of AR in higher education by providing recommendations to the stakeholders in SAn university settings to make future incorporation of AR as a learning method leading to success in SAn universities aligning with the new vision for 2030. Also, the aim is to determine students', lecturers', and e-learning departments' perceptions towards AR technology compared with the traditional methods of teaching and learning. Besides, this study sought to assess the AR experts' perceptions towards the developed AR framework.

The beneficiaries of the framework would be faculty members, e-learning departments' staff, and educational technology departments of these universities who would harness the educational benefits of AR technology to improve the learning outcomes. This study investigates these issues through three core research questions and objectives:

Q1 What are the factors that must be included in the AR framework for higher education in SA?

To ascertain the factors that must be included in the AR framework for high education in SA.

Q2 What are the perceptions of students, faculty members, and e-learning departments towards integrating AR as a teaching and learning tool compared with the traditional methods?

To determine students', faculty members', and e-learning departments' perceptions towards AR as a teaching and learning tool compared with the traditional methods.

Q3 What are the AR experts' perceptions towards the augmented reality framework?

To assess the AR experts' perceptions towards the augmented reality framework.

The first research question “What are the factors that must be considered in the AR framework for higher education in SA?” serves to ascertain the factors that must be highlighted for adopting AR by developing an AR framework for high education in SA. This is particularly important at this time when educational technology improvements have become ubiquitous. Despite the tremendous strides made by the Saudi Government in making technology available throughout its universities, the use of modern technology has been disappointingly underutilised (Alebaikan & Troudi, 2010; Al-Zahrani, 2015; Narayanasamy & Mohamed, 2013). Such a trend begs the question, “What are the factors that must be included in an AR framework for higher education in SA?”

The second research question “What are the students’, lecturers’, and e-learning departments’ perceptions towards the AR method compared with the traditional method of teaching and learning?” examines the students’, lecturers’, and e-learning departments’ perceptions concerning integrating AR technology as a learning method. As the literature review indicated, it is crucial to gain an understanding of participants’ views and awareness about a particular technology in universities to anticipate whether they will welcome or reject the use of this technology. Park and DeLong (2009, p. 88) stated state that “consideration of potential user reactions is a first step in delineating the technology adoption process within an organisation.”

The third research question “What are the AR experts’ perceptions towards the augmented reality framework” assesses the educational AR experts' perceptions towards the AR factors incorporation and their evaluation of the final framework. Experts who are most closely linked to this type of technology can provide an authoritative view of the issue and can provide the essential elements to be highlighted in order to integrate these technologies. Therefore, experts’ views were explored to unearth additional factors and validate the final AR framework factors.

3.3 Research Design and Rationale

The increase in technologies has created difficulties in understanding IT practices, impacts, usage, and capabilities. IT has become an integral part of individuals' lives and has evolved rapidly. Therefore, the IS researchers often face challenges in identifying sufficient findings and theories that provide essential insights into a phenomenon of interest. IS research has a broad potential for research approaches (Becker & Niehaves, 2007).

Consequently, a mixed-methods design can be employed as a powerful mechanism to help IS researchers to deal with such situations (Venkatesh et al., 2013). Saunders et al. (2012, p.160) have developed the 'Onion Design' design, which was followed in this study. This design is consisting of six parts, and the overall research design choices adopted for this study are depicted in Figure 29 below.

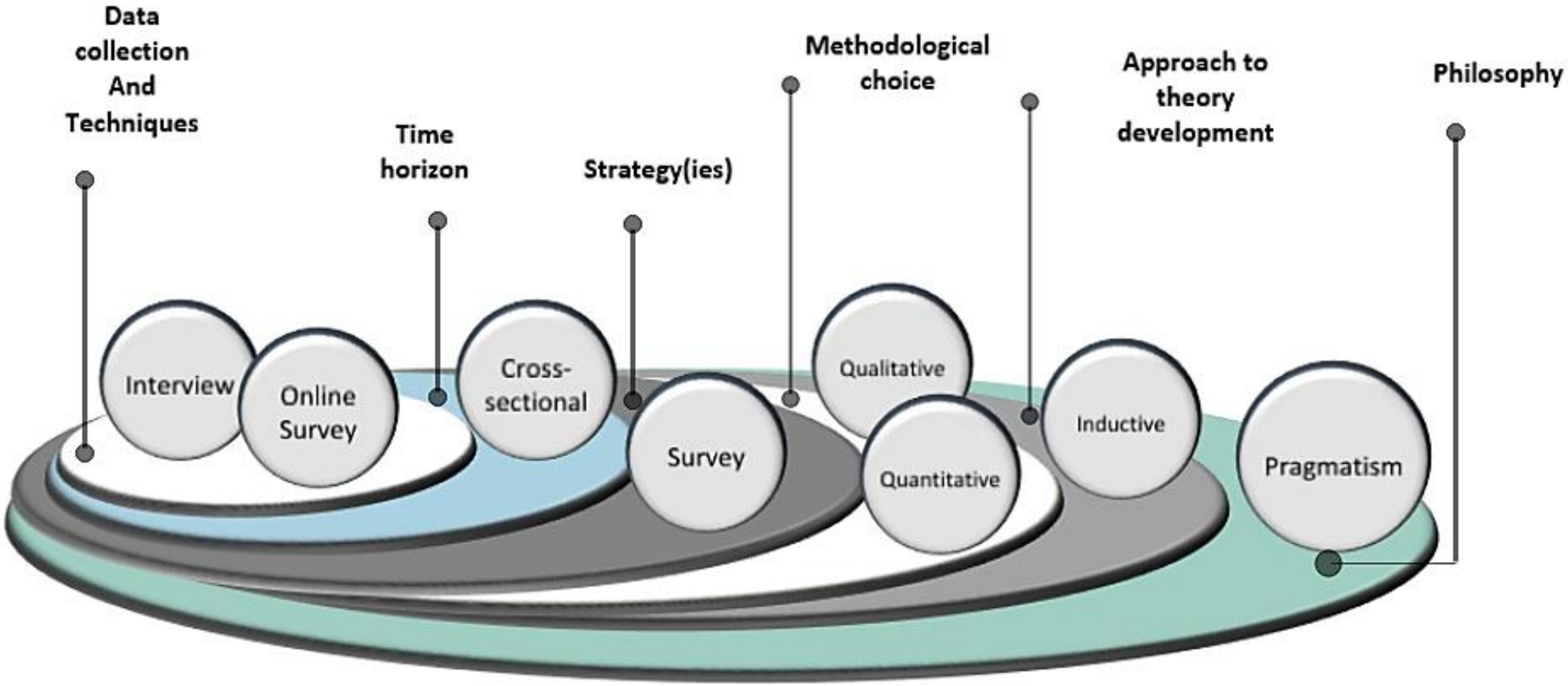


Figure 29: The Research onion. Adapted from: (Saunders. et al., 2016) (Prepared by author)

3.3.1 Research Philosophy

The research paradigm or philosophy is the first research ‘onion’ layer. This relates to the beliefs that direct the research (Cohen et al., 2000). Saunders et al. (2009) stated that the selection of the paradigm is the critical basis for research, as it sets out the tone for the development of knowledge and its necessary basic research strategy.

Since this study seeks to identify the crucial factors which are needed to have efficient use of AR in university teaching and learning, understand participants’ perceptions towards AR in higher education and produce recommendations to integrate AR, the research philosophy in this study is pragmatism with an inductive approach to explore and understand the integration of AR in education and then generate a conceptual framework.

Adopting a single paradigm was considered inappropriate. Instead, different paradigms ensure a more diverse perspective to minimise their weaknesses and provide a comprehensive overview of the adoption of technologies across Saudi universities. Pragmatism embraces both positivism and constructivism points of view. Pragmatism was suggested for IS researchers and recommended by mixed methodologists as one of the preferred paradigms for modifying the use of mixed-methods research (Venkatesh et al., 2013). Pragmatism was argued by Fendt et al. (2008, p. 437) as a paradigm that “allows dissolving this dilemma by focusing on asking the right questions and providing practical answers to those questions.” A pragmatic research philosophy has multiple values and stances, and it allows researchers to chase their concerns through long engagement and triangulation (Onwuegbuzie & Leech, 2005). It is a view that depends on the consequences of the research by addressing the research questions, and the objectives, approaches and methods used.

Mixed-method approaches are mostly associated with a pragmatic research philosophy, and the data is collected using quantitative as well as qualitative approaches to address the research objectives, questions and aim. Both objective and subjective views are considered in pragmatism to seek answers by placing the questions in the middle of the problem (Teddlie & Tashakkori, 2009). The advantage of selecting the pragmatic approach is that by using both quantitative and qualitative research methodologies facilitate information collection on a deeper level and make an inquiry into the complex phenomenon of natural and social contexts (Creswell, 2009; Morgan, 2007). Additionally, in the pragmatic approach, problems can be perceived differently in different scenarios which allow different interpretations of the phenomenon. According to Saunders et al. (2009), the pragmatic approach helps to form the basis of practical research by combining different views which assist in explaining the interpretation of the data in research.

Therefore, a pragmatism philosophy is used in this study to prevent methodological bias and to understand better the phenomenon being explored (Subedi, 2016). Besides the research questions is the rationale behind the selection of research approach, and qualitative or quantitative approaches alone will not wholly address the research problem, whereas a combination of approaches will (Creswell & Plano Clark, 2011). It will help to find what works well and find solutions to solve the problems that arise in the research process.

3.3.2 Research Approach

After selecting the paradigm, the next layer of the research ‘onion’, shown in Figure 29, is analysing two contrasting research approaches: deductive and inductive. The deductive approach is about proving the rightness or wrongness of a theory by testing hypotheses, while the inductive method is based on observations and data collection from which meaning and patterns result. Both approaches depend on existing literature as a starting point. However, the deductive approach shows that a theory is correct or wrong by creating, measuring and testing hypotheses, but the inductive method is based on data collection from which the researcher derives patterns and meanings (Gray, 2014). Based on Johnson and Onwuegbuzie (2004, p. 17) “ its logic of inquiry includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one’s results).”

Since this study is aimed at developing, understanding, and evaluating an AR framework for Saudi universities, it is exploratory in nature and thus has no beginning hypotheses. Instead, the main aim of this study is to understand and provide a holistic framework by the identification of the most common factors that would assist in the integration of AR in the higher education system. Hence, it needs to start with a broader idea of AR adoption factors and perceptions and should keep narrowing as more comes to light on the research context until an accurate representation of AR integration is reflected (Saunders et al., 2009). Therefore, the approach employed in this study is inductive.

Given the research purpose and problem statement, the present study employs a survey approach using the mixed-method research design (Explanatory Sequential Design), in which the data is collected through both quantitative (online survey) and qualitative methods (semi-structured interviews), analysed individually, and then merged to achieve the study outcomes (Ivankova et al., 2006; Johnson et al., 2007). This approach was found to be a highly popular approach among researchers (Subedi, 2016). According to Creswell and Plano Clark (2011), an explanatory sequential design comprises of two phases; quantitative data is collected first and then qualitative data to assist and describe the quantitative outcomes. Quantitative methods can be used to explore a relationship by observing how an individual's perceptions are related to a social issue or phenomenon (Marczyk et al., 2005). Then, explaining and clarifying the results of the quantitative data are supported by the qualitative results (Onwuegbuzie & Leech, 2004). For instance, this research aims to discover the factors which are needed to have a successful implementation of AR in teaching and learning approaches in universities; it focuses on identifying essential dimensions of integrating AR in SA universities and barriers towards it, and all dimensions are described and their correlations.

Applying an inductive approach to this research on the reasons why the universities of SA embrace or reject AR integration would require obtaining data that are rich enough to allow this research to investigate the phenomenon and recognise and explain themes and patterns relating to AR implementation. This study will then seek to incorporate these explanations into an overall conceptual framework. Therefore, this study took a mixed-methods (inductive) approach that is both quantitative and qualitative to examine the use and users' perspectives towards new technology in learning methods in SAn universities. The quantitative data provides the researcher with an overview of the opinions of universities' students and staff concerning AR integration within universities. The outcomes from the analysis provide a basis for designing interview questions (Leech & Onwuegbuzie, 2010) and helps the researcher to select the participants in the qualitative explanatory studies.

This study approach was selected because a general understanding of the research problem can be provided by the quantitative data and their subsequent analysis. The statistical results then will be further refined and explained by eliciting participants' views employing interviews (qualitative phase) (Creswell, 2003; Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998). The quantitative approach will be conducted first to understand students', faculty members', and e-learning department staff' reactions to the AR method, and to develop a set of new factors from the survey (Venkatesh et al., 2013). In other words, survey data will be used to construct the factors related to AR in learning; in the next phase, the qualitative method will be conducted with AR experts to explore the quantitative results from the survey in more depth to gain more insights, reasons, deeper understanding, and explanation of these constructed factors. According to Morgan (1998), in Explanatory Sequential Design, priority is given to the quantitative approach because the quantitative data collection often represents the most significant part of the mixed-method data collection process.

In this study, the decision was made, to begin with the quantitative data collection because the first aim of this study is to identify the factors of using AR as a learning method in Saudi universities. Morgan (1998, p. 367) said that "A simple way to decide which method should be used first is to build on the decision about which method will be principal." Additionally, Venkatesh et al. (2013, p. 18) reported that: "if IS researchers plan to conduct a study for which a strong theoretical foundation already exists, but the context of the research is novel or previous findings were fragmented and/or inconclusive, they may consider conducting a quantitative study first followed by a qualitative study to offer additional insights based on the context-specific findings or reasons for fragmented and/or inconclusive results in previous studies."

Therefore, this study started with a quantitative approach followed by a qualitative approach in which the qualitative stage builds directly on the results from the quantitative phase to use the qualitative data to explain the quantitative findings in more detail and to address all the research questions (Creswell, 2014) (please see Figure 30).

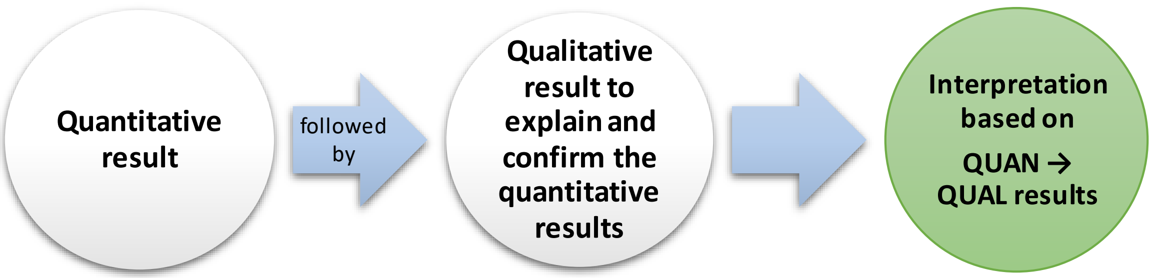


Figure 30: Explanatory Sequential Design (Creswell 2008, 557) (Prepared by author).

The design of explanatory mixed-methods enables the researcher to "Collect quantitative data first in the sequence. This is followed by a qualitative data collection. Researchers often present these studies in two phases, with each phase identified in headings in the report. This type of mixed-method the researcher uses the qualitative data to refine the result from the quantitative data" (Creswell, 2008, p. 560). The steps of explanatory sequential design and mixed-method in this research are illustrated in Figure 31:

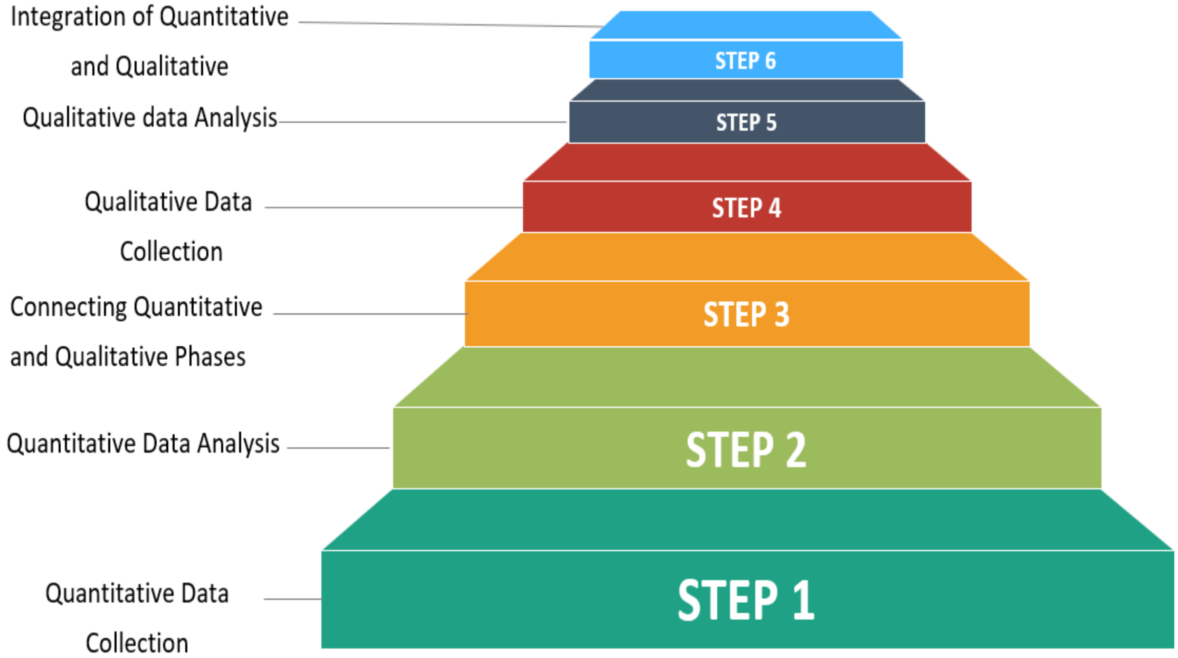


Figure 31: The steps of explanatory sequential design adopted from (Subedi, 2016) (Prepared by author).

3.3.3 Methodological Choice

Saunders et al. (2012, p. 164) stated that "regarding the selection of research methods, the researcher can either select 'Mono method' (single method), or 'Multiple methods', (more than one technique to collect the data and analysis procedure)." Mixed-method was defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study" (Johnson & Onwuegbuzie 2004, p. 17). The mixed-methods strategy is a procedure used for gathering both qualitative and quantitative data (Creswell, 2002; Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009) to accomplish research purposes. The mixed-method is mostly be related to the pragmatist philosophy, which works through an evaluating and measuring process to find a solution. The transformative mixed-methods approach was developed by (Mertens, 2007), which is a research process that provides an outline for understanding issues, cultural difficulty and, social justice. Figure 32 illustrates the research choices.

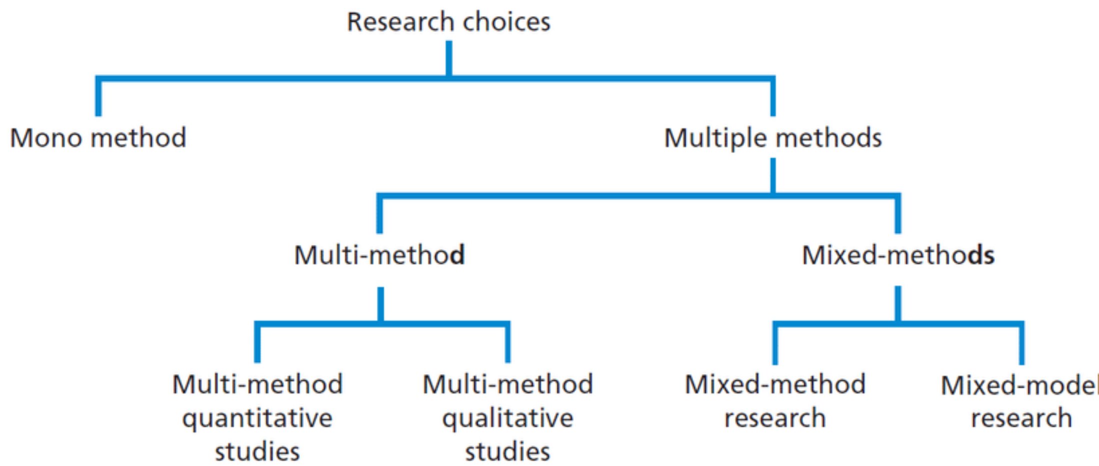


Figure 32: Methodological choice; adopted from (Saunders et al., 2016, p. 152).

The mixed-method comprises two dimensions (quantitative and qualitative) to collect the data, the quantitative dimension provides opportunities to illustrate the outcomes, while the qualitative dimension is required to gather perspectives about these outcomes. Conducting mixed-method research is more valuable than a single method in terms of theoretical contributions (Venkatesh et al., 2013). Moreover, Teddlie and Tashakkori (2003, 2009) stated that mixed-method research could address different questions at the same time, such as exploratory research questions and confirmatory. Mixed-methods research can provide great insights on a phenomenon by leveraging the strengths and eliminating shortcomings of quantitative and qualitative methods. Greater confidence would be instilled in research results through the triangulation and clarification of the results when conducting a mixed-methods approach (Greene et al., 1989; Venkatesh et al., 2013). Since 2011, the predominant method used in most AR studies is the mixed-methods approach (Chen et al., 2017). The purpose of using a sequential mixed-method approach is to provide a comprehensive picture of a phenomenon by using qualitative data results to deliver a rich explanation of quantitative data and analysis (Bryman, 2006; Venkatesh et al., 2013). In this study, the mixed-methods approach is used to provide a holistic understanding of the potential implementation of AR technology in education, and to unearth more factors. Tashakkori and Teddlie (1998) stated that when used in combination, quantitative and qualitative methods complement each other and allow a comprehensive analysis. Serin (2011) indicated that a mixed design is a factorial design that is extensively employed in the field of social science. It helps the researcher to reduce the threats to internal validity through the manipulation of one or more independent variables (Creswell, 2003). As well as measuring dependent variables that can affect a researcher's ability to distinguish between group search strategies.

Saunders et al. (2016) have outlined several possible research strategies and linked these to different research designs. Selection of the research strategy will be guided by the research questions and objectives, research philosophy, purpose and research approach, pragmatic concerns, and the amount of time that is available to collect the data (Saunders et al., 2016). According to Saunders et al. (2016), there are eight different research strategy choices as illustrated in Figure 33.

Figure 33: Research strategy choices (Prepared by author)

Yin (2003) suggested three conditions researchers can use to decide upon a research strategy. First, consider the research question type, such as “what”,” how” and “why”. Second, the level of concentration on contemporary opposed historical events. Third, whether the study requires control over actual behavioural events. Since this study does not examine the influence between independent and dependent variables (Saunders, 2009), experiments were not selected as a possible research strategy. Thus, the survey was considered to be most effective in this study based on the research questions. For instance, what factors make the implementation of AR more successful in SA universities, what are the factors that influence the environment of AR, and why these factors are related.

According to Saunders et al. (2016), The survey strategy is the most common and popular research strategy in business and management research and is most commonly used to answer ‘where’, ‘who’, ‘what’, ‘how many’ and ‘how much’ questions. Saunders et al. (2016, p. 181) mentioned that “Survey strategies using questionnaires are popular as they allow the collection of standardised data from a sizeable population in a highly economical way, allowing easy comparison.” The survey strategy was considered to be a suitable strategy for this study to reach a broad population of large SAn universities for the introduction of AR technology. Therefore, the survey strategy was chosen as the most suitable strategy for this phase.

3.3.4 Time Horizons

Time horizons also impact studies, and researchers might follow cross-sectional or longitudinal studies based on their research question. Cross-sectional research is defined as research that involves an investigation of a phenomenon at a given time, whereas longitudinal research is studying change and development over a more extended period of time (Sedgwick, 2014). The cross-sectional can be considered a “snapshot”, whereas longitudinal takes a “diary” perspective (Saunders et al., 2016, p. 200).

This study is not looking at changes that occur over time in Saudi universities but seeks an in-depth understanding of which factors might need to be incorporated and well-considered in the integration of AR in higher education in SA. Further, a longitudinal study is impossible in this study due to the access to all Saudi universities and time limitations for the completion of the study. The AR topic is developing day-to-day, and cross-sectional research has the advantage of allowing the researcher to conduct the study for the present period, which is beneficial for getting up-to-date information on the research topic. Accordingly, the time horizon will be cross-sectional in this study

3.3.5 Data Collection and Analysis

The last layer of the research 'onion' is data collection and analysis. When designing the research, it is essential to plan for the collection and analysis of the data (Creswell & Plano Clark, 2011). The design of this study requires verification of the unit of analysis, a strategy for the selected mixed-methods, and an overview of how the researcher collected and analysed the data. Hence, this research was performed in three stages. A conceptual AR framework was developed from the literature in the first phase. In phase two, quantitative data collection was conducted to examine the conceptual framework and enrich extra factors for the proposed framework. To verify the findings from the earlier phase, a qualitative study is conducted in phase three. Phases two and three develop the AR framework according to the factors found in the first phase; this addresses the first, second, and third research questions. More details regarding data collection, applications and duration for both phases are discussed in section 4.5 and 5.3.

These are illustrated in the subsections below. The sequential stages of the mixed-methods research design and research process are demonstrated in Figure 34.

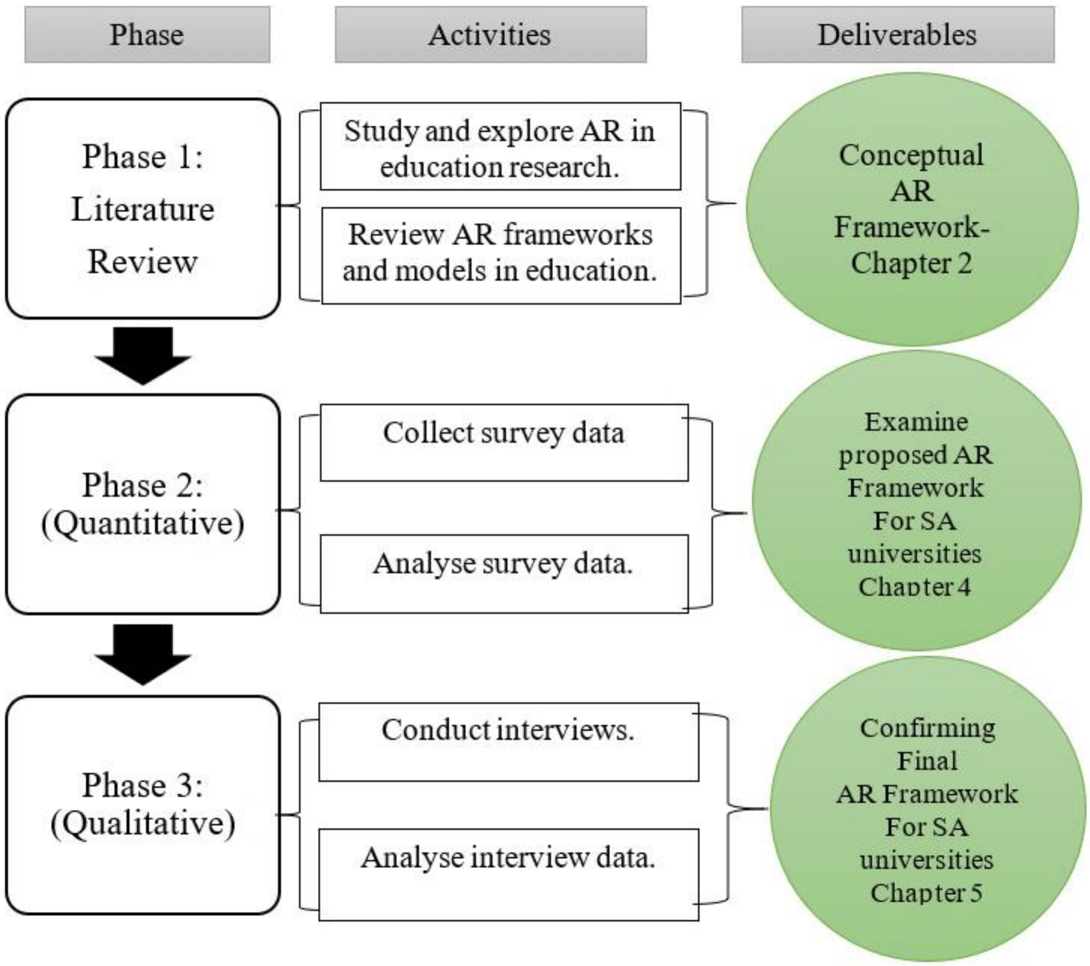


Figure 34: The sequential stages of the mixed-methods and research process (Prepared by author)

3.3.5.1 Developing a Conceptual AR Framework from the Literature

An extensive review of the literature related to AR used in educational settings was conducted in the first phase. Different resources were studied and reviewed such as conference proceedings, books, journal articles, published reports on AR in education, and studies published in Social Sciences, to ensure the different factors of AR used in the educational context are covered. Although there are many academic research frameworks and models discussing some AR factors in education, none of them explains all factors (please see section 2.10).

The literature indicated some factors related to integrating AR technology into tertiary education, but there was no agreement between studies, as discussed in section 2.9. Thus, a comprehensive framework is needed to bring together these factors, especially for developing countries, with a justification for each factor. An integrative review of the literature was conducted to identify factors that were confirmed or suggested by prior studies on the educational uses of AR. A conceptual framework was gradually formulated by combining all factors that were derived from the indicated resources. Saunders et al. (2016, p. 74) reported that an integrative review "critiques and synthesises the representative literature on a topic in an integrative way to generate new frameworks and perspectives on a topic."

Content analysis was adopted in current literature review than others because it is a commonly used technique and can be broadly defined as a method for identifying, analysing, and reporting patterns in the form of themes within a text (Braun & Clarke, 2006). Content analysis usually is used to analyse qualitative data (Zhang & Wildemuth, 2009). The qualitative content analysis was defined by Hsieh and Shannon (2005, p. 1278) as "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns." There are two types of content analysis, deductive and inductive (Elo & Kyngäs, 2008). The deductive approach uses the variables or concepts elicited from theory (Berg, 2012; Patton, 2002). In other words, the data analysis begins with the theory or findings of the relevant research as a guide for the initial codes. Conversely, exploring the research data and developing theories based on the text data is called an inductive approach (Saunders et al., 2016).

The researcher adopted both approaches for this study. A deductive approach was used to review the most relevant and significant research on AR use in the educational setting to develop a conceptual framework which was subsequently tested using data. After identifying a set of previous variables, keywords, themes and concepts for adopting AR technology in tertiary education from the literature, the content analysis method helped the researcher to deduce existing themes and data related to those themes. While identifying these variables and keywords, the researcher labelled and categorised them into themes forming the primary factors which include personal factors, sociocultural factors, economic factors, technological infrastructure factors, design and usability factors, training, pedagogical factors, support and maintenance, evaluation factor, emotional factors, and cognitive factors. These factors formulate the conceptual AR framework, as presented in Figure 28.

3.3.5.2 Phase 2: Online Survey (Quantitative)

In the quantitative phase, the draft AR framework was evaluated to validate the identified factors. A quantitative approach involves "deduction, confirmation, theory/hypothesis testing, explanation, prediction, standardised data collection, and statistical analysis" (Johnson & Onwuegbuzie, 2004, p. 18). The survey phase commenced with the questionnaire development, and its questions were primarily developed and derived from the literature review. In this study, the quantitative phase included the administration of an online survey in September 2017. In quantitative research, the survey method is one of the most widely used data collection approaches (Creswell, 2003; Myers, 1997). According to Saunders et al. (2016), the questionnaire is one of the most commonly used methods to collect data within the survey strategy. Many benefits are associated with using the survey method such as being cheaper than other methods, the flexibility and economy of the design, that surveys usually provided greater privacy than other methods, and representing a large population effectively (Cavana et al., 2001; Creswell, 2003).

Surveys can be utilised "in deciding policy or in planning and evaluating programs and conducting research when the information you need should come directly from people. The data they provide are descriptions of feelings and perceptions, values, habits, and personal background or demographic characteristics such as age, health, education, and income" (Fink, 2016, p. 5). Collecting data via a survey can be done in two ways: directly and indirectly. The direct procedure can be applied by asking questions to be answered by individuals, whereas the indirect procedure can include recording oral thoughts or written opinions (Fink, 2010).

For this study, the survey was used to explore the answer for the first and second research questions defined at the beginning of this thesis. Since these research questions are concerned with exploring the thoughts of students and staff regarding the factors and perceptions that influence AR integration in SA universities, an online survey was used to collect the data from the participants directly. Beginning with an online survey helped the researcher obtain an overview of what students and faculty members at Saudi universities thought about AR.

Validating the AR framework required an appropriate research method. This involved many processes such as reviewing the literature in-depth to ascertain the existing methods, identifying the target population and determining the best way to communicate with them. Consequently, it was considered that the most useful and appropriate method for validating the AR framework was the electronic survey approach. The advantages of using an online survey are: low-cost, time-saving for the researcher, and it is easy to distribute to respondents; moreover, it is under the full control of the researcher; it offers different formats when it is downloaded; the researcher can quickly remind the participants to submit their responses and thank them for their participation (Issa, 2013). Online surveys also enable the researcher to collect large amounts of data within a short time frame because it is accessible and relatively inexpensive. (Fink, 2016; Gordon & McNew, 2008). This questionnaire measured the respondent's perceptions, opinions and knowledge of educational use of AR technology as well as required demographics information to explore more factors for the proposed framework.

For the questionnaire, a Likert scale of five points—extending from "strongly disagree" to "strongly agree" with the neutral point being "neither agree nor disagree"—was selected to ensure the quality of responses and prevent respondents from being confused by the information volume in the questionnaire (Devlin et al., 1993; Melanie et al., 2013).

An online survey (questionnaire) varies based on how it is delivered and returned or collected (Saunders et al., 2016). There are three types of online survey: Web-based, PDAs or handheld devices and email (Gordon & McNew 2008). Web-based surveys offer an effective way of collecting data (Gordon & McNew, 2008), as shown in Figure 35.

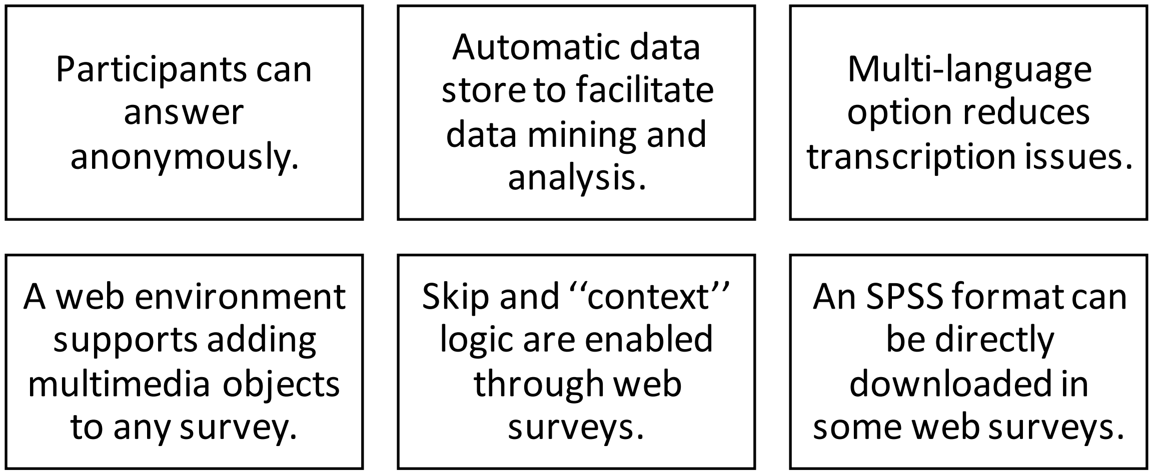


Figure 35: Benefits of web-based surveys (Prepared by author).

For these reasons, a Web-based survey approach was employed in this study. According to Farmer (2016), many online survey tools are available and used (e.g. Qualtrics, Snap Surveys and Survey Monkey) to allow researchers to design and manage surveys. In this study, the survey questionnaire was constructed, managed and distributed to the participants through the Qualtrics website (www.qualtrics.com). According to Boas and Hidalgo (2013), a Qualtrics web-based survey is considered a reliable tool to design survey questionnaires with credible features that allow online data collection and analysis

The online survey for this study was developed based on the initial framework and published in both Arabic and English languages. A professional authorised translation service translated it. To find and correct any issues before distributing the questionnaire, the survey instrument was pre-tested (Hair et al., 2010). Survey instrument face validity is determined after pre-testing it (De Vaus, 2002). For this study, the survey questions were tested and checked by research supervisors and experts of faculty members in the field of e-learning and educational technology before it was finalised. The survey consisted of a series of questions which are discussed in more details in Chapter 4.

3.3.5.3 Sampling Technique (Quantitative)

Sampling techniques help the researcher to reduce the amount of data needed to be collected by looking only at data from a small group rather than the entire population (Saunders et al., 2016). There are two types of sampling techniques: probability, or representative, sampling and non-probability sampling. Probability sampling utilises random sampling techniques of selection. Non-probability sampling techniques do not involve random selection, but rather it involves subjective judgement. The sampling technique that was used in this phase is simple probability random sampling to help the researcher to obtain the best results. Gravetter and Forzano (2012, p. 145) stated that "the logic behind simple random sampling is that it removes bias from the selection procedure and should result in representative samples." Details of the survey population, survey administration and response rate are provided in Chapter 4.

3.3.5.4 The survey population

An appropriate population of respondents are required for collecting the survey data. Identifying an accurate population was advised by Saunders et al. (2009), even if it involves merging information from multiple sources. The survey aims to pinpoint factors from the perspectives of participants about the use of AR in higher education. The collected data in this phase is used to confirm the factors required in an AR framework for SA. As Saunders notes: "In selecting a sample to study, it should represent the full set of cases in a way that is meaningful and which we can justify" (Saunders et al., 2016, p. 273). The sample population for this study was comprised of students, lecturers (academics), and ICT and e-learning department staff from SA universities. The indicated population is an appropriate choice as this study will focus on the introduction of AR technology in tertiary education. The participants were selected, as AR technology will be introduced in universities. These participants know and understand the characteristics of AR integration in higher education, which is what was being studied in this research. Ritchie et al. (2013, p. 113) indicated that two aims of selecting a sample are "to ensure that all the key constituencies of relevance to the subject matter are covered, and within each of the criteria there is enough diversity is included so that the impact of the characters concerned can be explored." Therefore, different information was sought from each of the participant groups in order to obtain different perspectives and adequately address research questions one and two, and to enable a more detailed exploration and understanding of the subject.

An online survey via Qualtrics was used to collect quantitative data. The sample size was determined according to Comrey and Lee (2013) and MacCallum et al. (1999), who suggested that the ideal sample size for factor analysis is 500 participants. As will be explained in section 4.5, the researcher recruited the participants at random by distributing an invitation letter via a university email as well as social media such as LinkedIn, WhatsApp, Facebook, and Twitter. Duration for the data collection period for the online survey and distribution methods are discussed in more detail in Chapter 4. Moreover, the researcher was working at one of the SA universities, and his close connections enabled him to access the participants and stakeholders. Also, it was easier for the researcher to administer the survey as the students were available and willing. Approval to conduct the research was obtained from the Standing Committee for Research Ethics in universities.

3.3.5.5 Analysing Survey Data

The raw data collected from questionnaires requires data analysis software to clean the data and check for errors (Creswell & Plano Clark, 2011). This study used the SPSS (version 25) for data analysis. To identify a set of factors, the factor analysis technique was utilised in this study. Factor analysis is a procedure to minimise the number of variables by using the differences between the observed variables (Brown & Onsman, 2013). Factor analysis comprises two types of analysis: Exploratory factor analysis (EFA), and Confirmatory Factor Analysis (CFA) (Alhija, 2010). EFA was utilised to identify factors grouping items to be considered in AR integration framework in the context of SA higher education sector.

EFA is a statistical approach to discover a relatively broad number of variables underlying structure (Alhija 2010). EFA "explore the underlying dimensions of a construct. The primary considerations inherent in the use of factor analysis include conceptual/theoretical considerations, design considerations, statistical considerations, and reporting considerations; it is exploratory in nature" (Alhija 2010, 162). EFA is commonly used in psychology and education, on the data collected from questionnaires to identify factors (Brown & Onsman, 2013). The factor analysis produces an enhanced set of factors, which enables the researcher to elicit a more consistent understanding of the data than the initial grouping. More details of the factor analysis are presented in Chapter 4.

3.3.5.6 Phase 3: Interview (Qualitative)

Although questionnaires can be utilised as the only data collection method, linking them with other methods in a mixed or multiple method research design is encouraged by Saunders et al. (2016). In this stage, the quantitative data collected via an online survey was supported/supplemented by qualitative data gathered during online asynchronous interviews. Accordingly, for this study, the interview was used to validate the first research question and explore the answer for the third research question defined at the beginning of this thesis. Also, the qualitative stage was conducted to gain a better understanding and to explore the reason why and how these factors are essential to be considered in AR adoption framework. This phase was guided with questions and aspects that arose from the quantitative phase. Qualitative methods offer an effective way of providing "complex textual descriptions of how people experience a given research issue. It provides information about the "human" side of an issue—that is, the often contradictory behaviours, beliefs, opinions, emotions, and relationships of individuals" (Mack et al., 2005, p. 1).

Kaplan and Maxwell (2005) provide five main reasons for using qualitative methods to evaluate computer IS:

- Understanding how a system's users perceive and evaluate that system and what meanings the system has for them.
- Understanding the influence of the social and organisational context on systems use.
- Investigating causal processes.

- Providing formative evaluation that is aimed at improving a program under development, rather than assessing an existing one.
- Increasing the utilisation of evaluation results.

Qualitative data are collected primarily from interviews, observations, and documents, and the diversity of these systematic techniques is used to enhance the data. According to Schultze and Avital (2011), interviews are considered one of the most widely used research methods in IS research. Interviews can provide a more comprehensive data set by telling personal stories (Denscombe, 2010). The personal contact between the respondents and the researcher will lead to collecting more valid data and ensure that the questions are understood by respondents (Thomas et al., 2011). During the interview, participants had the opportunity to expand and clarify their ideas and identify what they considered to be critical factors. Some authors (Monette et al., 2011; Wilkinson & Birmingham, 2003) indicated that the interviews were designed to match the needs of the participants; therefore, more honest and meaningful answers were expected to be given by participants.

Most interviews happen on a face-to-face basis. However, interviews may also be conducted using the internet to collect the data (Saunders et al., 2016). Internet interviews can be conducted in two ways. The first one Synchronous refers to conducting interviews online in real-time, while the second type, Asynchronous, is conducted offline at a time of the respondents choosing (see Figure 36).

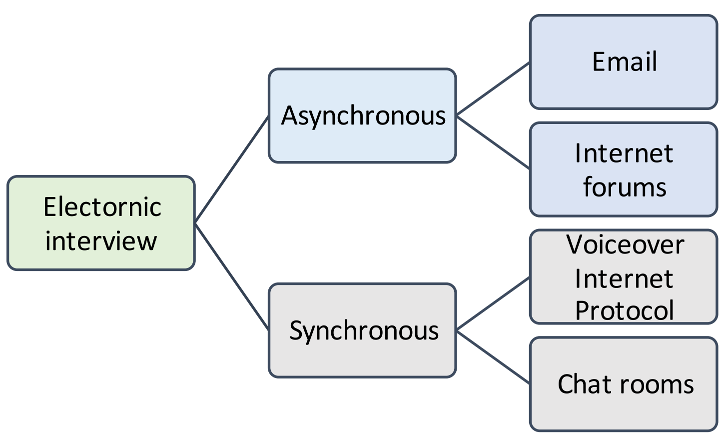


Figure 36: Electronic interview (Saunders. et al., 2016)

In the asynchronous electronic interview, the researcher conducts the interviews by the exchanging of text or by a web link between the interviewer and the participant. Applying this type of interview can involve gaps in time between asking a question and providing an answer. Using an electronic form also helps the researchers to interview the population regardless of their location.

In the interview phase, the researcher used online semi-structured interviews conducted in non-real-time, or asynchronously, with open-ended questions with a selected number of subjects to collect the data necessary to achieve the research objective and to support the data obtained from the online survey results. Using open-ended questions provides more flexibility (Seidman, 2013). Creswell and Plano Clark (2011) consider the interview as a method that provides an understanding of the issues beyond the survey, as well as a space for more detailed accounts from the interviewee.

Thus, the interviews were conducted to elicit a holistic dataset about the adoption of AR in SA universities (Bryman, 2012). Asynchronous interviews were conducted being one of the fastest-growing internet-mediated methodologies to date (O’Connor et al., 2008). The following format was followed to conduct the online asynchronous interview: the researcher obtained the participant’s email address and received the respondent’s agreement to participate. An email that contained the interview questions as a web link was sent out to the participant, inviting them to respond to the interview questions and to return the completed answers to the researcher. The interview questions were all delivered to the participants through the Qualtrics website.

O’Connor et al. (2008, p. 4) point out: “A distinct advantage of the email interview is that interviewees can answer the interview questions entirely at their convenience. There are no time restrictions, and this can be particularly valuable when participants are located in different time zones. The lack of temporal restrictions also enables both the interviewer and interviewee to spend time considering their questions and answers, and perhaps composing, recomposing and editing responses to questions.” Furthermore, using text-based e-interview has the advantage of eliminating difficulties associated with other methods of recording and transcription such as accuracy, cost and participants' apprehension because the data are recorded as participant's responses are typed in (Saunders et al., 2016).

The interview questions were semi-structured. Longhurst (2009, p. 580) defined Semi-Structured Interviews (SSI) as "the verbal interchanges where one person, the interviewer, attempts to obtain information from another person by asking questions." The advantage of SSI is that a list of questions is pre-defined by the researcher as a guide and the additional interview questions can be asked to explore answers further thoroughly (Saunders et al., 2009). SSI was suggested by Teddlie and Tashakkori (2009) to be used as part of the mixed-methods design to explore and explain and/or validate themes that have resulted from the questionnaire phase. In this research, SSI was used for different reasons: (a) they are valuable in collecting qualitative data (Harrell & Bradley, 2009); (b) the greater potential of having a definite understanding between the interviewee and interviewer (Wengraf, 2001); (c) they explore emotions and feelings (Kajornboon, 2005); (d) they increase validity by enabling interviewees to provide information in more detail (Harrell & Bradley, 2009); and (e) they allow participants to expand and clarify their ideas, and identify what they consider to be critical factors (Denscombe, 2010).

In this study, a list of factors that emerged from the quantitative phase was explored and assessed through the qualitative method with the educational technology and AR experts. SSI was conducted to explain better the findings derived from quantitative data and analysis and to answer the third question in this study from the experts' positions. Questions for the interviews, as elaborated in section 5.2, were formulated by the researcher using the survey results as a guide. The interview questions were developed to unearth additional factors, clarifying uncertainty in the quantitative results, seeking confirmation and more information about the identified factors, and evaluating the framework. For these reasons, SSI is considered to be qualitative and is mainly helpful for explanatory research.

Consequently, the interview phase is ideal for validating the answers for the first research question and exploring the answers for the third research question.

It has been suggested that the sample size of the SSI should be between five and 30 interviewees (Creswell, 2013), while Morse (1994) recommends at least six. Spradley (1979) proposed that the number of interviewees for any project should be between 25 and 30 interviewees. Warren (2002) indicated that usually, 20 to 25 interviewees are adequate for a qualitative study. Some authors (Guest et al., 2006; Johnson, 2001) stated that there is no recommended number of interviewees as long as the state of theoretical saturation is achieved. According to these studies, the determined sample number for this study should be 10 to 20 participants. The SSI questions, the period for the data collection and distribution method are discussed in more details in Chapter 5.

3.3.5.7 Sampling Technique (Qualitative)

In this phase, the researcher used purposive sampling to answer the research questions and to meet objectives. Dudwick et al. (2006, p. 3) reported that "qualitative methods typically refer to a range of data collection and analysis techniques that use purposive sampling and semi-structured, open-ended interviews." Purposive sampling is one of the non-probability samples that is chosen based on population characteristics and the study objective. It is about a limited number of participants that have knowledge or expertise in the area being investigated. Purposive sampling can be categorised into six types.

The purposive sampling six categories are (Saunders et al., 2016): an extreme case; heterogeneous; homogeneous sampling; critical case sampling; typical case sampling; theoretical sampling. Also, the researcher uses the Snowball sampling process, which is where participants refer the researcher to other potential participants. A few people, at the beginning of this study, were asked to nominate other people whom they considered would be relevant for a study on AR technology in educational settings. According to Denscombe (2010, p. 37), "Snowball sampling is an effective technique for building up a reasonable-sized sample, especially when used as part of a small-scale research project."

3.3.5.8 The Interview Population

The selection of potential interviewees in this study was based on their experiences with AR (expert knowledge), particularly in the education context, and educational technology. That is, those who are very conversant about AR technology and those who have used and implemented AR applications to facilitate the use of technology in learning. People who are highly familiar with AR will be able to provide the researcher with rich information and various perspectives on the potential use of AR in higher education. Eliciting the perspectives of experts on educational AR is necessary to cover all critical factors and elaborate on the importance of AR factors. The interviews aim to collect data from experts and professionals who reflect their experiences regarding AR technology factors and their potential integration in SA universities. The most beneficial interviewees had to be decided on next. Since AR technology will be introduced in the university environment, the criteria for the targeted potential population are:

- Academic personnel at universities in SA who have expertise in IT and ICT use in education.
- E-learning department staff who have experience in the field of AR.
- Designers of educational AR technology.

Those were identified from each university's website or university communication centre, and their contact details regarding obtained either directly from the website or LinkedIn. Each participant was then contacted by email to obtain a participation agreement. Semi-structured internet-based interviewing was conducted with individual participants from different universities and institutions' staff via the Qualtrics platform. Details of the SSI participants, the administration is provided in Chapter 5.

3.3.5.9 Analysing Interview Data

The qualitative data that arose from the interviews were analysed using general qualitative analysis techniques such as NVivo software (version 12). The thematic analysis technique was applied to analyse the interview data. The thematic analysis which Braun and Clarke

(2006, p. 78) refer to as 'foundational method for qualitative analysis', was applied to analyse the qualitative data for further exploration by identifying key patterns, themes and relationships from the data set. Braun and Clarke (2006, p. 6) defined thematic analysis as a "method for identifying, analysing, and reporting patterns (themes) within data." Emerging themes were identified through applying thematic analysis, and relevant meanings were obtained based on understanding the individuals' experiences in detail. In this study, the researcher used inductive and deductive thematic analysis and coding, where the themes were derived from the results of the online survey phase, and some were created based on the data. Braun and Clarke's (2006) six phases of thematic analysis were used in this study to guide the data analysis. These phases are familiarising yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. A coding technique was also employed by using segments of data to sort the data into categories that helped to understand the data. The codes used in this study are defined by the researcher, which involves using a priori codes drawn from AR framework. More details about the interview data analysis technique are presented in Chapter 5.

3.4 Research Trustworthiness

The reliability of the research and results provided are ensured by several tests. As Larson and Miller point out: "it is more appropriate to use the word trustworthy for mixed-methods studies because it applies to both quantitative and qualitative research" (Larson & Miller, 2005, p. 128). The trustworthiness of the research processes was guided by the five criteria for research evaluation that were proposed by Lincoln and Guba (1985): validity, reliability, credibility, transferability and confirmability.

3.4.1 Validity

According to Calmorin et al. (2007), validity refers to how well research measuring instruments can measure what it is purported to measure. As noted by Gray (2009, p. 155) "to ensure validity, a research instrument must measure what it was intended to measure." This can be described briefly as an essential step in designing measuring instruments (in this case, the online survey and the interview) that measure the real issues that the research is claiming to investigate. Gray (2009, p. 155) has provided seven types of validity: “internal, external, criterion, construct, content, predictive and statistical validity.” Internal validity refers to the relationships of the questions that are related to cause and effect, and it is considered as a high internal validity when there is a less chance of confounding in a study. External validity is to measure how it is possible the results of a study can be generalised to another setting, large population and/or overtime. Criterion validity is the extent to which a measure predicts an outcome for another measure. Construct validity is related to measuring attributes and abstract concepts (e.g. perceptions, ability, and knowledge). Content validity is about validating the research content by creating an accurate link “between what is taught and what is tested” (Gray, 2009, p. 157).

Predictive validity focuses on how well the research can predict a phenomenon at a later point in time. Finally, statistical validity is the extent to which the study creates the use of appropriate statistical methods and design (Gray, 2009). These described procedures of validity are considered in this research. The online survey was reviewed and pre-tested by PhD supervisors and a number of experts, lecturers and academics in the technology and education domain to ensure face validity. Also, a pilot test was administered to ascertain the suitability and reliability of the survey questions. Furthermore, a mixed-methods approach was adopted in order to increase validity and collect information from a large sample in universities.

3.4.2 Reliability

Reliability is related to “the extent to which a research instrument is dependable, consistent, and stable” (Calmorin et al., 2007, p. 55). Cronbach’s (1951) coefficient was conducted in this research to gauge the reliability of scales or the average correlation of items in a survey instrument. This coefficient is one of the most popular and widely used statistical reliability tests (Cronbach, 1951). Internal consistency reliability is discussed in more detail in Chapter 4.

3.4.3 Credibility

Credibility is about associating the research study's findings with reality to reveal the truth of the research study's findings (Macnee & McCabe, 2008; Shenton, 2004). Credibility determines whether or not the research results represent reasonable information provided from the original participants' data and is a valid explanation of the original views of the participants (Graneheim & Lundman, 2004; Lincoln & Guba, 1985). Denscombe mentions that steps needed to be taken "that can help with the task of persuading readers of the research that the data are reasonably likely to be accurate and appropriate" (Denscombe, 2010, p. 297). Nevertheless, they will help by providing a guarantee that the obtained information has been originated and verified following good practice.

According to Saunders et al. (2016), credibility includes a range of techniques such as triangulation (which involves using a multi-method of data collection to confirm the validity and add richness to the research), and participants or member validation (which involves going back to the participants to check data, analysis and interpretations to confirm its accuracy by permitting them to add comments on and correct it to validate it). In this research, the research questions and aims were well defined with the consistent and appropriate methodology. Besides, nineteen (19) SSI interviews were conducted to enhance the validity/credibility of the data to reveal the reality in the data and to explore issues found in the online survey. Also, the interview itself was used as a form of respondent validation.

3.4.4 Transferability

Transferability is like the parallel criterion to external validity. As Saunders points out: "transferability is providing a full description of the research questions, design, context, findings and interpretations, the researcher provides the reader with the opportunity to judge the transferability of the study to another setting in which the reader is interested in research" (Saunders et al., 2016, p. 206). Transferability is not concerned with whether the study included a representative sample; instead, it is about how well the findings of a research study apply to other settings (Lodico et al., 2010). In this study, the researcher made an effort to ensure transferability by establishing a full description and reporting the phases of the research and process.

3.4.5 Confirmability

The researcher can use specific strategies to imply confirmability, determining the accuracy of the findings of the research study that could be confirmed by other researchers (Lincoln & Guba, 1985; Stoner, 2010). In this study, the interviews were utilised as an active phase to allow the researcher to explore a unique perspective to the study since the researcher conducted interviews with the respondent alone. This view is supported by Given (2008) who indicated that verifying confirmability through two main goals of the qualitative phase: (1) it will help the researcher to understand phenomena from the research participants' perspective and (2) to understand the meanings people give to their experiences.

3.5 Ethical Considerations

In line with Curtin University policy, and to ensure there was no potential harm or risks to the participants, the researcher obtained ethics approval, number HRE2017-0425 approved on 05-Jul-2017, from Curtin University Human Research Ethics Committee to start the data collection phase of both the survey and interviews. Each method needed to be approved and the researcher requested approval for both phases. However, in the second phase, the researcher submitted an amendment request form with the changes listed in the interview questions. All universities granted the researcher permission to conduct this study with students and members of academic staff and e-learning department staff (Appendix 1). Also, all universities were informed about the researcher's aim before the research was conducted.

Additionally, the confidentiality clause assured participants that their details would not be shared with any other researcher, PhD committee, or a third-party organisation. All surveys and interviews were conducted in English, except in those cases where the participant in the online survey preferred it to be in Arabic. In this case, the online survey and participant's comments were translated using a third-party translator. The interview questions were answered in English by the experts. To assure participants that they would not experience any loss of privacy, harm, discomfort or embarrassment as a result of this research, they were shown the Ethics Committee's approval documentation. As a part of this research, all participants' data have been kept anonymous and confidential and saved under secure conditions at Curtin University for seven years after the research has ended and then it will be destroyed.

3.6 Conclusion

This chapter illustrated the decisions that were made in this research based on each layer of the research 'onion', beginning from the philosophy selection to the time horizon and design. In this study, the pragmatic philosophy was selected due to its plurality to guide this research. The explanatory sequential design favoured the inductive strategy for which several research methods were analysed. A sequential process combining quantitative and qualitative phases as a mixed-method design was thought to best to answer the research questions.

The selection of a mixed-methods design was illustrated and justified. The benefits of the mixed-methods approach were discussed. This was followed by more details about the quantitative and qualitative data collection methods used in this research. Three main phases included in this study were: (1) developing a conceptual AR framework from the literature, (2) examining a proposed framework via the quantitative phase, and (3) validating the AR framework via qualitative data collection. The survey was selected in the first phase to find the influential factors in adopting AR in higher education. The latter phase involved interviews to explore the quantitative results from the surveys in more depth from the experts' perspectives to gain more insights, reasons, deeper understanding, and explanation of these constructed factors. EFA was selected to analyse the survey data. Survey outcomes were then used to construct the interview questions and answer the third question.

General qualitative analysis techniques such as NVivo software was used to analyse the interview data. Finally, this research was guided by the following criteria: validity, reliability, credibility, transferability and confirmability criteria to provide the trustworthiness of the research processes. The next chapter will explain phase two: an examination of the proposed AR framework through quantitative data collection.

Chapter 4. Quantitative phase

4.1 Introduction

The previous chapter addressed several paradigms in the research and served to place this study within the context of a mixed-methods approach, which is used in quantitative and qualitative research. The selection of methods of the study was also discussed, including the quantitative and qualitative research design issues, data collection techniques, and target population activities in both phases of research.

This chapter provides an overview of the quantitative phase. This study sought to determine the factors that need to be included when developing an AR framework for SAn higher education and ascertain students', teachers', and teaching and e-learning departments' perceptions towards AR in comparison with traditional teaching and learning methods. As stated in the previous chapter, to acquire a greater understanding of the area being studied, different sources were utilised for data collection. The researcher used a sample of 729 cases (501 students, e-learning and 228 academics staff). The survey was conducted to discover the perceptions of SA students and academics regarding the educational use of AR and to discover the factors that facilitate the adoption of this technology in SA universities. This chapter explains the survey conducted to refine further the initial AR framework with factors derived from three sources (students, academics and e-learning staff) in detail. This phase was then used to explore the answer to the first and second questions of the study.

This chapter provides details of the survey design, questionnaire structure, development of the survey questionnaire, target population, managing the survey questionnaire, and analyses of the survey data. It also explains how the results of the factor analysis created an enhanced factors list, which was added to the AR framework. Finally, the enhanced AR framework is illustrated.

4.2 Designing the Survey

As stated previously, this survey aims to understand students', academics' and e-learning staff's perceptions towards the AR teaching method, and to create several new factors from the survey data. Also, the survey questionnaire was designed to determine the perceptions and the factors influencing the adoption of AR as a learning tool in SA universities and to generate a comprehensive framework. The survey questionnaire was designed to investigate the factors that must be included in the development of an AR framework for the higher education sector in SA, as identified from the literature and the previous studies and models. The survey instrument design and development are discussed in the following subsections.

4.2.1 Questionnaire Structure

The questionnaire was structured to ensure that it covered all the aims of the survey. Figure 37 shows the four main sections of the questionnaires designed for students and staff. The staff and student surveys differed in two sections, as different information and perspectives were sought from the respective participants.

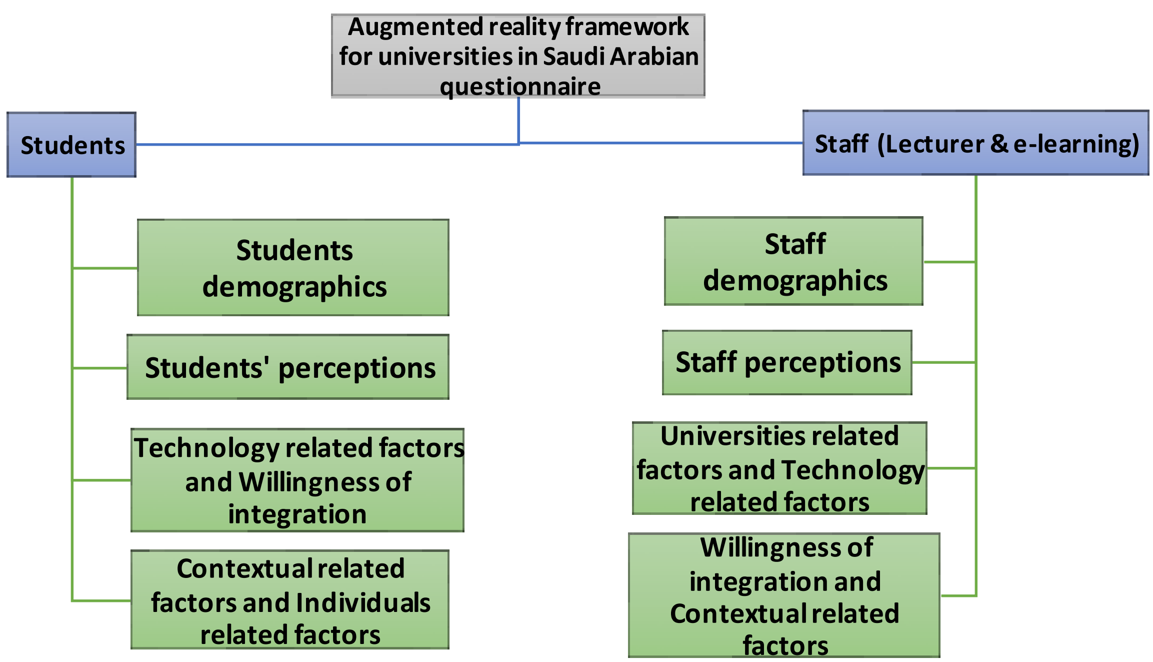


Figure 37: AR survey structure (Prepared by author)

The first section in the student and staff questionnaires was designed to elicit demographic information regarding age, gender, job title, and technology experience. In the second section of the survey, both students and staff were asked about: (a) their perceptions towards AR, and (b) the contribution of AR in education as a learning method. In the third section of the students' questionnaire, the questions addressed some of the factors required when integrating AR in the Saudi higher education sector, such as willingness, design, and usability. The questions in the third section of the staff questionnaire covered university-related factors and technology-related factors, including AR integration and implementation issues. The last section of the student questionnaire was developed to identify contextual and individual-related factors that might influence the effectiveness of using AR as an educational tool, such as sociocultural, norms, beliefs, cognitive, and emotive factors. Whereas, the last section of the staff survey posed questions relating to sociocultural factors and the readiness to integrate AR. Adopting questions or code themes from other studies that meet the researcher's needs is more efficient for researchers who wish to compare their findings with previous studies, and this facilitates the evaluation of reliability (Saunders et al., 2016). The survey questions and measurements were either derived from the literature review or developed by the researcher, except for the first section, which elicits demographic information.

4.2.2 Developing the Survey Questionnaire

The online survey was generated via Qualtrics Survey Software. The development of the survey required taking into consideration the interpretation of previous studies and models for the adoption of AR technology as learning tools in higher education, which were extracted from various sources (articles and published reports on AR in education, academic research sources, and studies published in Social Sciences Citation). The structure of the survey was simple and included clear instructions. Further, the questions were designed to flow in a logical order, beginning with general and natural questions that could be answered and including a title for each section. The time estimated for completion of the online survey was 15 minutes; the survey was a maximum of four pages in length. The survey is included in Appendix 3

The first demographics section contained questions with multiple choices that require one answer from a list of options to elicit each respondent's age, gender, job title, the field of study or work, education level, computer experience, and interest in technology. The remaining sections of the questionnaire identified AR adoption factors consisted of a matrix-of-choice format multiple answers to save space and to enable groups of similar questions to be answered quickly (de Vaus, 2002; Saunders, Lewis, and Thornhill, 2009; Saunders et al., 2016). Also, the survey included filter questions to identify participants who did not meet the target demographic. For example, the survey was filtered based on the job title, so when participants clicked on staff option from the job title list, s/he would automatically skip the questions reserved for students.

In this survey, a Likert scale of five points extending from "strongly disagree" to "strongly agree" with the neutral point being "neither agree nor disagree" was selected to ensure the quality of responses and prevent respondents from being confused by the information volume in the questionnaire (Devlin et al., 1993; Melanie et al., 2013). In the second section, for both students and staff, the questions were intended to measure two factors related to participants' perception of AR based on using the first stage of Rogers' 'diffusion of innovations' theory as a conceptual signpost. The researcher developed a set of questions to investigate the participants' perceptions of incorporating AR in education. This questionnaire included two subscales: usefulness of using AR as an educational tool, and the AR pedagogical value in learning. At least three variables comprise each factor.

A Likert scale of five points was applied for the questions in the second section. In the third section of the students' questionnaire, two factors were presented, and two subsections measured their willingness to adopt this technology and AR design and usability; at least three variables were presented in three different statements for each factor. These questions also used a five-point Likert scale and a matrix-of-choice format. The sections of the students' online survey are depicted in Figure 38 below:

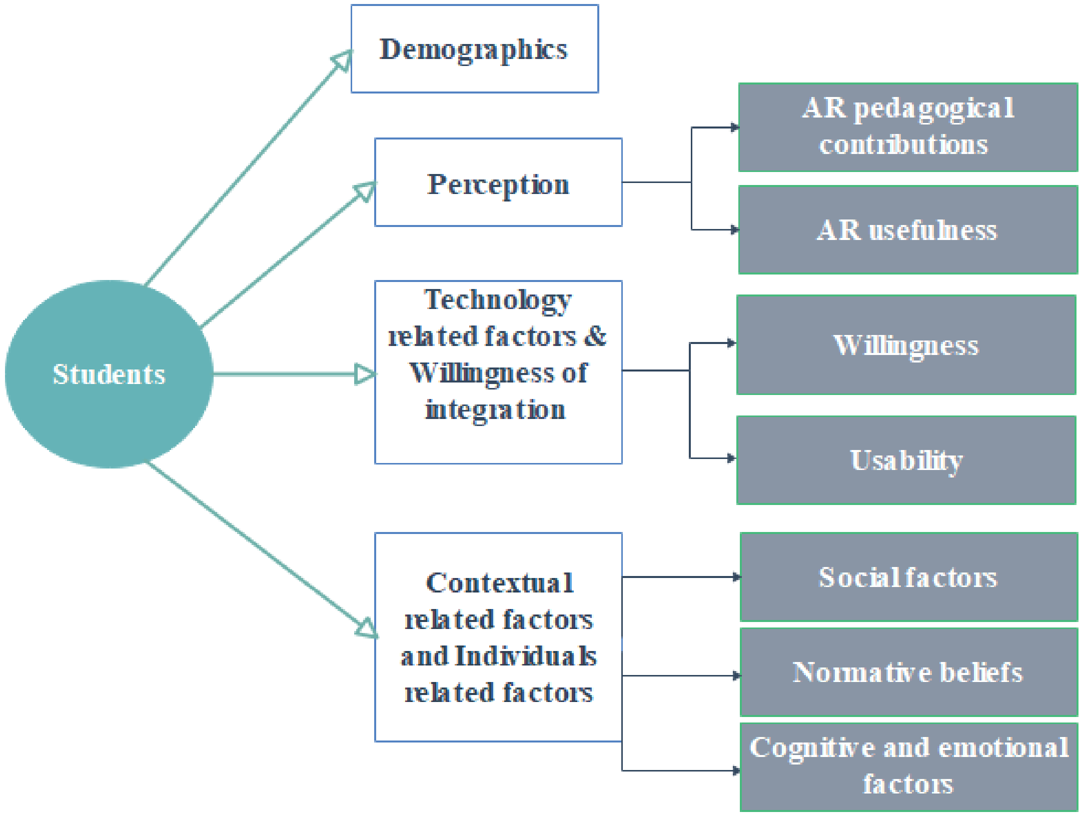


Figure 38: Sections comprising the students' online survey (Prepared by author)

The final section of the students' survey contained four subsections, which included questions intended to measure the influence of some factors on the adoption of AR for SAn education. In the first question, a Likert scale of five points was applied for the statements to measure students' opinion regarding cognitive factors when AR is integrated into learning. Some of the cognitive questions were adopted from Cheng (2017) and Küçük et al. (2016) and modified to align with a five-point cognitive load scale. The second question called for rating-type responses, which allowed respondents to indicate their feelings and emotional response when adopting AR in learning activities. The third question included rating statements related to contextual factors to measure sociocultural norms and beliefs that might influence the successful implementation of AR in universities of SA. The normative beliefs statements of Marcinkiewicz and Regstad (1996) were adopted. The statements were modified to add lecturers, the dean, and the head of the department as “significant others” besides the students as used in the questionnaire of Marcinkiewicz.

The third section of the staff questionnaire consisted of subsections that included questions to elicit participants’ opinions on technological infrastructure, organisational support and development to implement AR in universities, and usability. These were illustrated as rating-type questions, which enabled participants to show their level of agreement or disagreement. The sections of the staff online survey are shown in Figure 39 below.

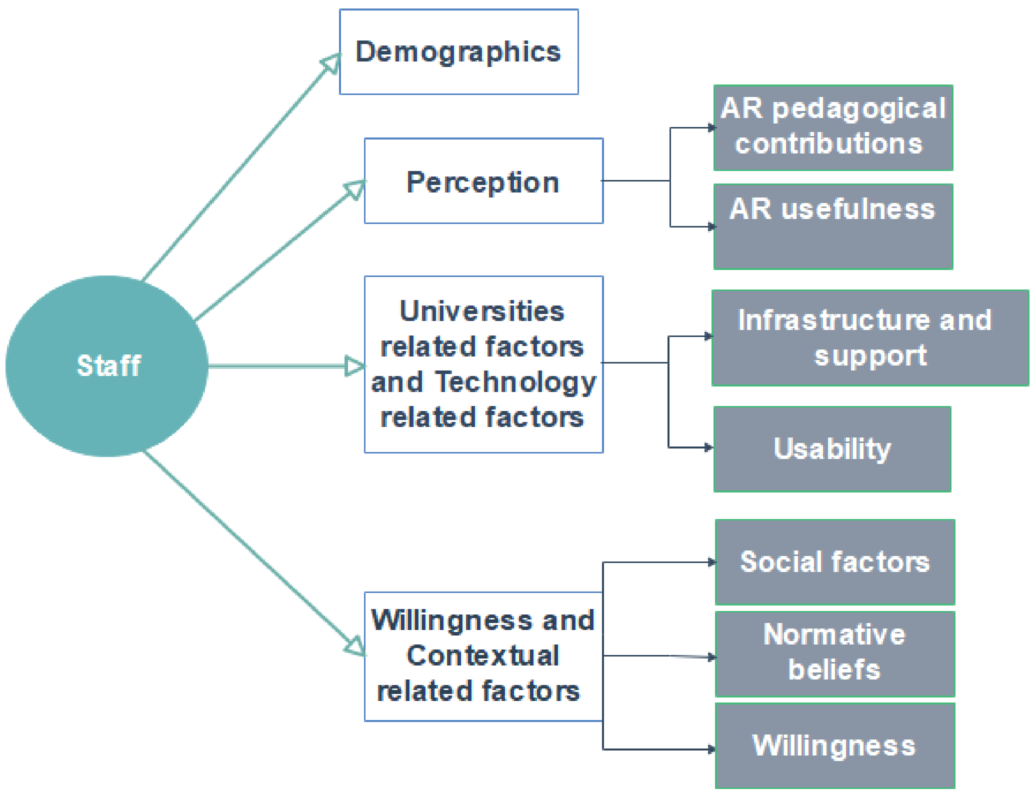


Figure 39: Sections comprising the online staff survey (Prepared by author)

The last section of the staff survey consisted of three subsections, which included questions anchored to the five-point Likert scale intended to measure the readiness of academic staff to use AR in their teaching and professional activities. Some of the items were adopted from Boj et al. (2016). The second and third subsections used rating-type questions to elicit e-learning and academic staff opinions regarding the influences of sociocultural norms and beliefs about the integration of AR in SA universities.

Moreover, the AR adoption survey also included open-ended questions to ensure content validity by inviting participants to add any comments regarding the integration of AR in Saudi universities and other factors that might facilitate or influence the integration of AR in the universities and to incorporate them in the framework. Using Qualtrics, included with the questionnaire, was a welcome screen and a cover letter clarifying the aims of the survey and the objectives of the study. The cover letter also included an explicit request for the participant's consent in the welcoming screen. The approval from the university's Ethics Committee was also indicated. Before sending the questionaries, the researcher obtained approvals to gain access to the selected population. The potential participants were also provided with information about the research topic.

A video demonstration illustrating the concept of AR technology in teaching and learning in a university environment was embedded in a link along with the surveys. The AR demonstration illustrated the characteristics and use of AR technology. It included an introduction to AR and different demonstrations about the potential use of AR in different educational subject domains such as maths, English, science, physical education, and languages. The purpose of the demonstration was to ensure that participants could better grasp the idea of AR as a means of teaching and learning.

Furthermore, information was provided regarding the expected time needed to complete the survey and guidelines concerning each question and how to proceed through the survey. The survey design and development processes are depicted in Figure 40.

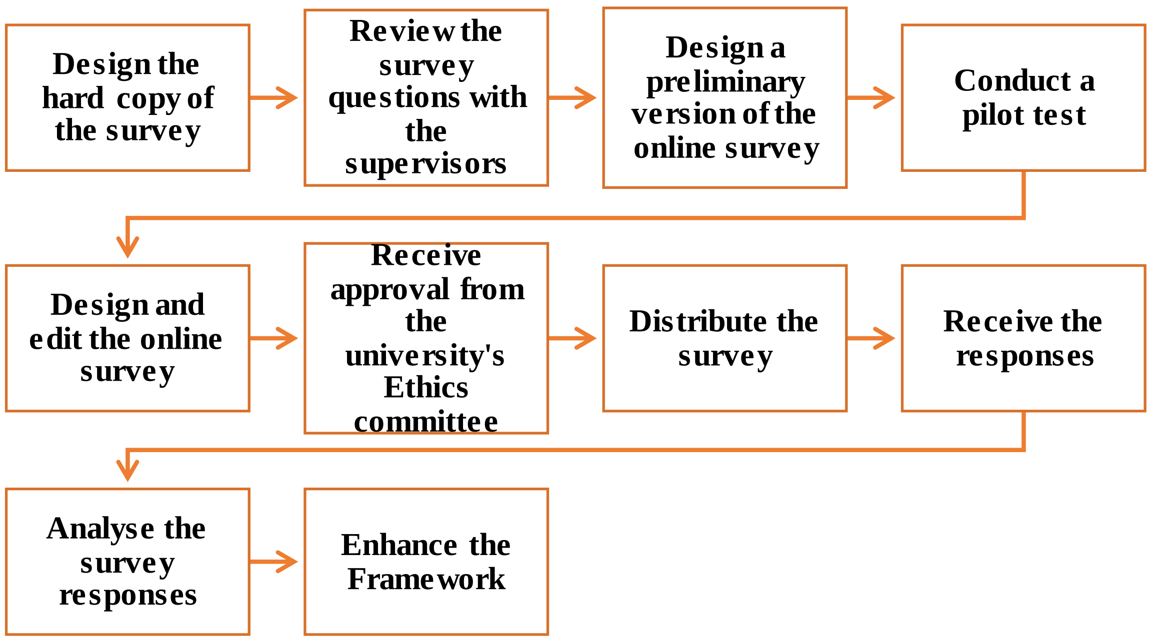


Figure 40: The survey design and development process (Prepared by author).

4.3 Reliability and Validity of the Survey

Several attempts have been made to ensure the reliability and validity of the study and the results. The following subsections will discuss these reliability attempts.

4.3.1 Pilot Test

The questionnaire was reviewed, and PhD supervisors pre-tested it to ensure face validity. A pilot test was also administered to a good number of lecturers and academic friends to obtain feedback by asking them to think aloud as they were answering the survey questions. According to Saunders et al. (2016), a pilot study helps the researcher to ascertain the suitability and reliability of the survey questions. As Fink (2013) pointed out, each completed pilot questionnaire needs to be checked to enable the researcher to discover whether respondents have had any issues answering and understanding questions and following the questionnaire instructions correctly.

The participants who undertook the pilot survey were similar to those who answered it for the primary survey. Ten participants were recruited for the pilot survey, comprising students, academic members, lecturers, and master's degree students. Based on feedback from participants in the pilot test, several well-conceived changes were made by re-wording some questions and breaking down other questions into two components to ensure clarity of understanding. For instance, there was one question related to whether the technology is suitable in terms of age and gender; pilot study participants suggested that this be reworded as two questions as age and gender are separate variables.

Also, it was noted the participants took more than 15 minutes to finish the survey due to the survey structure. The researcher then reorganised the survey into sections and reworded some questions as short statements for each factor instead of writing the whole question. After analysing the pilot survey data, the researcher found some issues with the results due to differences between the Arabic and English language versions. For example, if a participant selected "agree" in the Arabic version of the survey, this was equivalent to selecting "somewhat disagree" in the English version, thereby leading to incorrect results. Therefore, changes were made accordingly. Appendix 3 includes the final version of the questionnaire. Also, three experts in the field of computer science, e-learning and educational technology were requested to verify the instrument of the survey. The experts reviewed the survey contents of the instruments to ascertain the extent to which the instruments addressed the research questions (McMillan et al., 2004). Generally, the instruments of the survey were valid for the research questions based on the experts' feedback.

4.3.2 Reliability of Internal Consistency

Internal consistency reliability is a technique used in ensuring the success of a survey or test in measuring what the researcher intends to measure. Fink (2010, p.158) stated that internal consistency "refers to the extent to which all the items or questions assess the same skill, characteristic, or quality." Internal consistency is related to the homogeneity of the items in measuring the same construct (Henson, 2001). A scales-based survey is considered to be reliable when the scale performance is consistent to ensure that the outcome of the analysis will not generate random and/or systematic errors (Cooper and Schindler, 1998). Cronbach's Alpha is one of the most popular and widely used statistical reliability tests to test internal consistency. Cronbach (1951) developed Cronbach's alpha coefficient to gauge the reliability of scales or the average correlation of items in the survey. The alpha coefficients range in value from 0 (inconsistent) to 1 (good consistency). The higher the value, the more reliable the scale. According to Hair et al. (2010), the standard threshold of the alpha coefficient value is 0.70. The internal consistency reliability using the alpha coefficient applied to the surveys had a value of .923 for the academic staff and .908 for the students' survey, which is almost consistent.

4.4 The Survey Population

As discussed in section 3.3.5.4 and shown in Table 7, the population sample for this study consist of students, e-learning department staff, and teachers (academics) from SAn universities. Surveys were sent to all universities from the sample population to ensure an adequate response rate (Baruch & Holtom, 2008; Cycyota & Harrison, 2002).

Table 7: Survey population

Targeted sample	**Total number of participants**
Students	501
Faculty members (academics)	146
E-learning department staff	82
TOTAL POPULATION	**729**

The survey was distributed to a 50% systematic sample of 2568 students, with 501 completed and 669 unacceptable, with an overall 39% response rate that is regarded as acceptable and recommended by Baruch and Holtom (2008). The survey was also distributed to a 50% systematic sample of 1300 academics and e-learning staff, with 228 completed and 152 unacceptable, with an overall 35% response rate.

4.5 Administering the Survey Questionnaire

The survey questionnaire was designed via Qualtrics Survey Software, and a web link (hyperlink) was used to distribute it. Universities in SA have an ICT communication centre containing all students, academic staff and employee contact details. These universities' approvals were already obtained to send the surveys, so the researcher could provide recruitment material for these universities' contact centres, involving a hyperlink to sample population. One week after sending the survey, the follow-up process started. However, Baruch and Holtom (2008) detailed that follow-ups are not always helpful to boost the rate of response.

With three follow-ups, the number of responses after three months was still quite low from both students and academic staff. To raise the number of student responses, the researcher decided to visit some universities and personally invite students on campus to complete the survey via an iPad device. Additionally, the researcher had a great connection with some of the academic staff, both male and female, since they had studied together overseas and were now lecturers and professors in various universities in SA. The researcher's friends encouraged their students to complete the survey by giving them extra marks for their participation. Furthermore, the link was distributed through social media to academic and lecturer 'groups' in SA, encouraging them to participate and distribute the survey among their friends.

The researcher was able to acquire a further number after six months of student and academic staff responses. Distributing the survey through social media such as Facebook and WhatsApp groups helped to increase the number of responses more than via emails. Besides, the sharing of the survey link in students' Blackboard by their lecturers and professors facilitated collecting the data from targeted students.

4.6 Survey Data Analysis

This survey was designed to comprise different sections, as previously mentioned. In the first part, demographic questions were asked, whereas the remaining sections consisted of questions about the integration of AR technology and the factors influencing this integration. The respondents' profiles and characteristics were explored in the first part of this section. Data management and analysis were performed using SPSS version 25. Percentages and frequencies of the demographic data for both students and academic staff are presented to make the analysed data conveniently readable.

After defining and understanding the demographic data, it is crucial to conduct factor analysis to refine the factors that emerged from the literature. As mentioned earlier, this study makes a significant contribution to the literature by classifying the factors that have been discussed in previous studies, as the most influential factors regarding AR adoption, to produce a set of factors that present a holistic approach to integrating AR in Saudi universities. Hair et al. (2010) asserted that factor analysis provides a better method of condensing the information contained in many original variables into a small set of factors that are highly interrelated while retaining most of the information.

To obtain excellent construct validity, two techniques were used to analyse the survey data. As mentioned previously, the survey questionnaire was divided into sections. Firstly, the data was analysed using EFA based on the survey sections for students, e-learning, and academic staff. The second step involved generating data analysis using EFA for the whole survey for students, e-learning, and academic staff. The data analysis was generated by using these steps to establish the reliability and validity of the surveys' measurements by ensuring that each scale accurately represented the intended concept (Hair et al. 2010). Accordingly, the researcher compared the findings of both approaches to ascertain whether the same findings were obtained for the constructs. In the final stage, the researcher combined the survey's findings from students, academic and e-learning staff to enrich an improved set of factors that contribute to an AR framework for SA. In the sections below, each technique is explained in more detail.

4.6.1 Exploratory Factor Analysis (EFA)

The EFA can be utilised to decrease the variables to a smaller group of robust factors or latent variables (Hair et al. 2010). The most appropriate statistical analysis method to apply to the questions of this research is EFA. The essential findings of an EFA is a factor loading matrix. EFA is conducted to identify a small number of common factors that linearly explain the correlation between the original variables. The EFA method is employed to ascertain the underlying dimensions of a specific set of variables without the impact of predetermined hypothetical constructs (Floyd & Widaman, 1995). Williams et al. (2010) suggested five steps for clustering the survey items into a smaller set of new factors as summarised in Figure 41: (a) suitability of the data; (b) extraction method; (c) determination of factor numbers; (d) rotation method; and (e) data interpretation and labelling. Each of these EFA steps is explained in detail in the following sections.

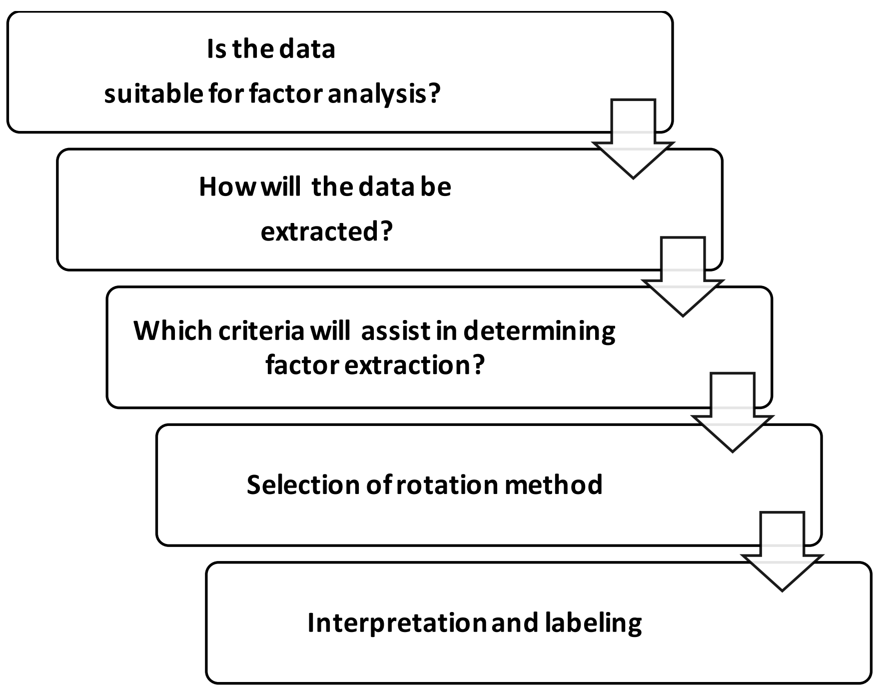


Figure 41: Exploratory factor analysis steps approach adapted from Williams and Onsman (2012)

4.6.2 Determining the Suitability of the Data for Factorability

Two criteria were taken into consideration to establish the factor analysis for this research: sample adequacy and sample size (Mundfrom, Shaw, & Ke, 2005). Commenting on sample size, Field (2000, p. 443) argued "the most important factors in determining reliable factor solutions was the absolute sample size and the absolute magnitude of factor loadings." There are diverse opinions and several guiding rules that recommend large sample sizes. For instance, Tabachnick and Fidell (2013) suggested that 300 is the minimum sample size for factor analysis. Hair et al. (2010) recommended that the size of the sample should be 100 or larger.

Some researchers (Pett, 2003; Tabachnick & Fidell, 2013) proposed their guide to sample sizes based on the Comrey and Lee (1992) rules which are: 100 as weak, 200 as fair, 300 as good, 500 as very good, and 1000 or more as excellent. Others argue that a sample size of around 150 cases is sufficient when there is a high factor loading (Pallant, 2011). As Bryant and Yarnold (1995, p. 100) stated "one's sample should be at least five times the number of variables. The subjects-to-variables ratio should be five or greater. Furthermore, every analysis should be based on a minimum of 100 observations regardless of the subjects-to-variables ratio."

In this study, the data set has an adequate sample size of 729 cases (501 students with 24 variables, 228 academic and e-learning staff with 34 variables). To determine the significance level of the factor loading, this study followed the Hair et al. (2010) instructions to determine significant factor loadings as presented in Table 8.

Table 8: Guidelines for defining significant sample-based factor loadings adopted from Hair et al. (2010).

Factor Loading	**The sample size needed for significance**
.30	350
.35	250
.40	200
.45	150
.50	120
.55	100
.60	85
.65	70
.70	60
.75	50

Further, to determine factorability, two statistical tests were used in this study to determine the adequacy of the sample and whether or not it was suitable for factor analysis. These measures of sampling adequacy (Kaiser, 1974) tests were the Kaiser-Meyer-Olkin (KMO) and Bartlett's test (Bartlett, 1954). To assess the adequacy of the sample, the sphericity test of Bartlett should be significant (p <.05 or smaller) (Pallant 2011). As noted by Tabachnick and Fidell (2007, p. 614) "the test is likely to be significant with samples of substantial size even if correlations are very low. Therefore, use of the test is recommended only if there are fewer than five cases per variable." For the KMO test, the acceptable score is no less than .70, whereas .80 or higher is marvellous (Hair et al. 2010). To assess the sampling adequacy, the following criteria should be used (Kaiser, 1974, p.183):

- ".90 = Marvellous
- .80 = Meritorious
- .70 = Middling
- .60 = Mediocre
- .50 = Miserable
- Below .50 = Unacceptable"

All factorability criteria and tests were applied to all survey data. The survey data was found to meet the criteria for employing factor analysis in this study. The students' survey confirmed factorability with subject to KMO value is .906, which is above .6, and Bartlett’s test is significant (p <.001).

The academic and e-learning staff survey also confirmed the factorability of structure items; the Kaiser-Meyer-Olkin measure of sampling adequacy was KMO (.901), above the suggested value of .6, and Bartlett's test of sphericity was significant (p < 0.001).

4.6.3 Factor Extraction Method

Extraction aims to eliminate common variance in the first factor as much as possible (Child, 2006). There are various methods for extracting factors, the most common being: Principal components analysis (PCA), maximum likelihood, principal axis factoring (PAF), generalised least squares, alpha factoring, unweighted least squares, and image factoring. PCA and PAF are widely applied in the literature. PCA was established by Pearson (1901) and adapted for factor analysis by Hotelling (1933) (Pett et al., 2003). As Pett et al. (2003, p. 11) point out, “the aim of PCA is to duplicate the correlation matrix using a set of factors (also called components) that are fewer in number and are linear combinations of the original set of items.” Furthermore, according to Schmitt (2011), PCA is a standard extraction method for EFA because it does not require data normality and is used as a dimensionality reduction technique. Therefore, PCA was performed in this analysis since the data to be analysed used the default EFA extraction method, and this is not possible for normally distributed data.

4.6.4 Determining the Number of Factors

Pallant (2011, p. 184) stated that factor extraction "involves determining the smallest number of factors that can be used to best represent the interrelationships among the set of variables.” Hair et al. (2010) suggested several considerations when determining the number of factors to be extracted:

- Eigenvalues rules (or Kaiser’s criterion), where those factors with a value greater than 1.0 are maintained. In some cases, the eigenvalues technique generates an unreasonable number of factors. Therefore, this technique can be used only as a preliminary means of estimating the number of factors (Tabachnick & Fidell 2014).

- According to research aims or previous study, the researcher can predetermine the number of factors.
- Adequate factors to satisfy an exact percentage of variance explained are generally equal to 60% or higher.
- The scree plot test is an approach used to identify the optimum number of resultant factors before the clear break where the path of the curve switches and becomes horizontal (or "elbows") in a plot of eigenvalues.

In this study, the researcher applied all of the above techniques to decide on the number of factors to be extracted. The researcher decided to implement multiple techniques for extraction. Firstly, the researcher started with Kaiser's criterion to acquire an initial idea of the generated set of factors. This was followed by variance explained analysis to identify factors that met 60% or greater of the total variance. Finally, a scree plot analysis was applied to identify factors above the inflection point (elbow). Relevant figures and tables are presented in the survey analysis findings section.

4.6.5 Selection of the Rotation Method

Factor rotation is a better interpretation of the ambiguous variables (Yong & Pearce, 2013). The rotational method helps the researcher to obtain meaningful and simple factor solutions. Rotational methods can be classified as oblique rotation and orthogonal rotation based on a correlated and uncorrelated factor solution. Oblique rotation is when the factors are correlated, while, orthogonal rotation is where the factors are uncorrelated (Yong & Pearce, 2013). In this research, the researcher tried both rotations and decided to apply the orthogonal technique due to the complexity of oblique rotation and the fact that most factors did not correlate ($r < +/- .30$). Data reduction to obtain a small set of uncorrelated factors is also a benefit. In this research, the underlying factors were expected to be independent of each other therefore, an orthogonal rotation was selected. There are two common orthogonal techniques: Quartimax and Varimax rotation. Varimax rotation is a widely preferred option because of its simplicity in the columns of the factor matrix and reduces the number of variables by preserving high loadings on each factor (Pallant, 2011; Yong & Pearce, 2013). Therefore, for this research, Varimax rotation was used for interpretation of the findings.

4.6.6 Factors and Items Identification

Evaluation of the rotated factors was conducted via SPSS 25 to determine the factors' structure and their corresponding item factor loadings. Because there are two sample sizes in this study (students N=501 and academic staff N=228), EFA was conducted separately for students' responses and staff's responses. Firstly, factors were identified by the largest loadings after examining all variables in the rotated component matrix. In this study, the minimum highest value differed for the students and academic and e-learning staff. Comrey and Lee (1992) classifies the acceptable range of factor loading over 0.7 as outstanding loads, over 0.63, as very good, over 0.55 as average, and over 0.45 (exclusive) as bad, between 0.32 and 0.45 as fair. Based on the Hair et al. (2010) suggestion for cut-off points, the minimum highest value in the students' analysis was .30, while .40 was the minimum highest value in academic and e-learning staff analysis.

To decide further what items to retain, the researcher examined each variable's communalities to evaluate whether it met a satisfactory level of explanation (Hair et al., 2010; Tabachnick & Fidell, 2013). Pallant (2011) suggests that a communality less than 0.3 should be removed as it does not align with other items clustered under the same factor. Furthermore, Costello and Osborne (2005) recommended that the variables that did not load on any precise factor need to be eliminated. Likewise, internal consistency was conducted for both analyses to determine their reliability. Cronbach's coefficient evaluation was used to measure the degree to which factor items correlate with each other. The value of Cronbach's α in both analyses exceeded the requirements, which is Cronbach $\alpha \geq 0.7$. Therefore, in this study, items were removed from the students' analysis if the factor loading was weak or less than (.30) or the communality was not within the acceptable level (<.30). The same steps were checked in the academic and e-learning staff analysis, and items were removed if the factor loading was poor or worse (<.40). Likewise, the researcher followed the recommendations of Costello and Osborne (2005), whereby variables were removed if they did not load on any specific factor. Finally, Cronbach's alpha was tested for both analyses to determine the reliability of all items and each factor. Table 9 summarises the analysis process applied in this study.

Table 9: Summary of the analysis process

Process	Criteria
Factorability	• sample size adequacy • Bartlett's Test of Sphericity significance ($p < 0.05$) • KMO > 0.6
Extraction method	PCA
Determining the number of factors	• Eigenvalues rules (or Kaiser's criterion)>1 • Percentage of variance explained ≥ 60% • Scree test
Factors rotation method	Varimax technique
Identify factors and items	• Cronbach $\alpha > 0.7$ • Factor loadings ≥ 0.4 for staff analysis • Factor loadings ≥ 0.3 for students' analysis • Communalities around 0.4

4.7 Findings of Survey Data Analysis

This section presents the outcomes of the students, academic and e-learning staff surveys data analysis. The obtained results were used to include new survey outcomes in the AR framework for SA. For the purpose of analysis, EFA was separately conducted for both the students' survey and the academic staff survey. Hence, the researcher decided to generate EFA for the students' survey and academic staff survey based on survey sections and whole surveys. This section has been organised according to the following subsections. In section 4.7.1, students' survey analysis and findings are explained. Results from the academic and e-learning staff survey are presented in section 4.7.2. The enhanced AR framework for SA is demonstrated and discussed in section 4.8.

4.7.1 Student Online Survey

In the following subsections, the student online survey analysis and finding are illustrated. This includes demographic information, descriptive analysis and EFA analysis.

4.7.1.1 Analysis of Student Demographics

As mentioned previously, the survey was distributed to three different groups of participants (students, academic staff, and e-learning department staff). In total, 729 respondents returned completed surveys. Five hundred and one students studying at Saudi universities were recruited for this study, returning (70%) of the total participant responses. Of the initial cohort of 501 students, (274 or 54.7%) were male, and (227 or 45.3%) were female (please see Figure 42).

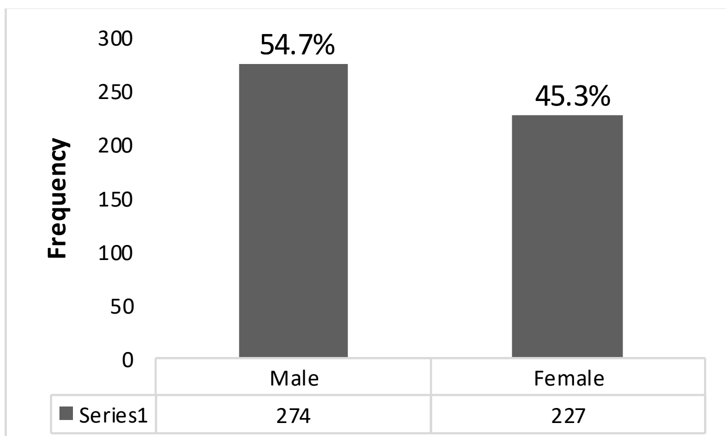


Figure 42: Students' gender

Furthermore, the respondents were classified into seven age groups: 18 – 23 years old; 24 – 28 years old; 29 – 33 years old; 34 – 38 years old; 39 – 44 years old; 45 – 50 years old; 50 years old and above. Most of the student participants (88.6 %) were aged between 18 and 23 at the beginning of the university study. Around (38, or 7.6%) of student respondents were aged between 24 and 28. Less than 15 of the student respondents were aged between 29 and 33. Only (5, or 1 %) of student respondents were between 34 and 38 years old, and no students' respondents were older than 40 years old. Table 10 illustrates the age of students' participants.

Table 10: Ages of student respondents

Category	Frequency	Percent
18 - 23	444	88.6%
24 - 28	38	7.6%
29 - 33	14	2.8%
34- 38	5	1.0%
Total	**501**	**100.0**

The bar chart below in Figure 43 shows the distribution of students according to various faculties. From the chart, it can be seen that the largest number of students (103) were enrolled in health science, followed by science and engineering students. The reason for a large number of health science and engineering students is that the targeted universities are highly regarded for their science and engineering programs.

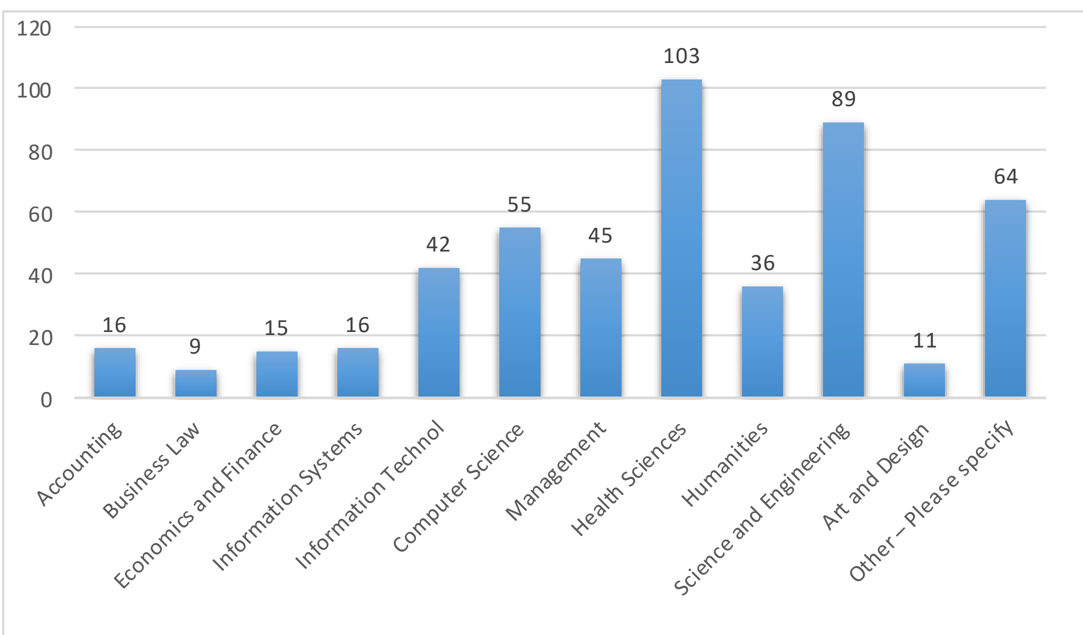


Figure 43: Students' faculties

In response to the computer experience question, most students (56%) comprising both male and female had an intermediate experience level, and 28% of student participants were advanced in using computers, while only 8% indicated a beginner level of computer experience (please see Figure 44).

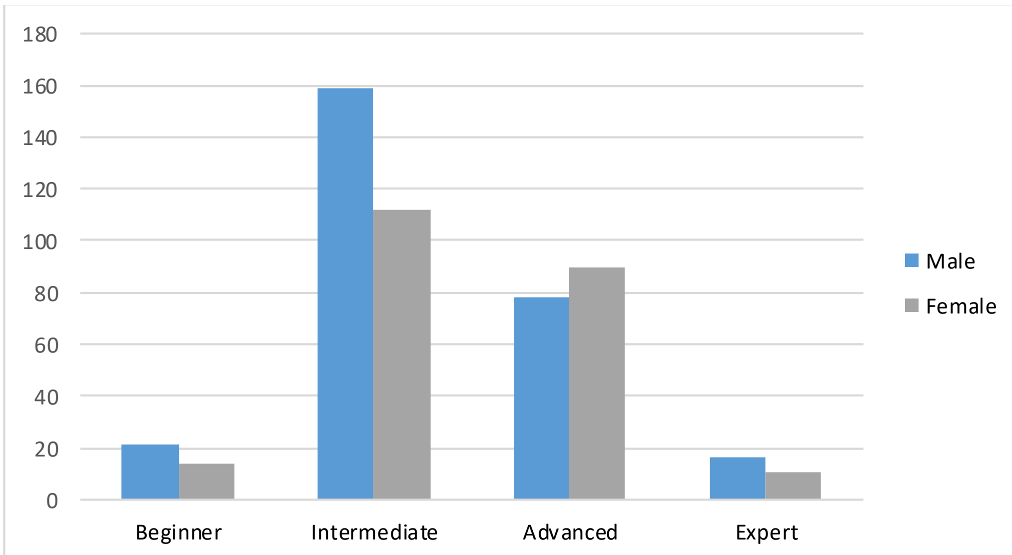


Figure 44: Students' level of computer experience

When the results for the two genders are compared, it is apparent from Table 11 below that more females than males are advanced in computer experience.

Table 11: Level of computer experience based on gender

	Beginner	Intermediate	Advanced	Expert
Male	21	159	78	16
Female	14	112	90	11
	8%	56%	28%	6%

Furthermore, students were asked to indicate their interest in technology. The overall response to this question was very positive. Most of the students in SA universities are interested in new technologies; approximately half of the respondents (48%) have a high level of interest in technology, while 47% indicated a medium level of technology interest.

A small number (20, or 4%) of students indicated a low level of interest in technology. Figure 45 provides an overview of students' responses regarding their interest in technology.

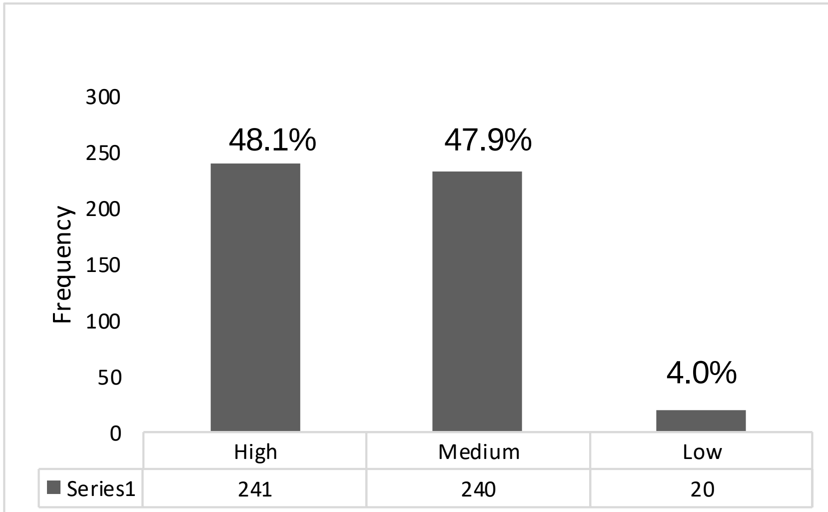


Figure 45: Students' interest in technology

As can be seen from Table 12, the male students reported a high interest in technology (50%) more than the female students.

Table 12: Interest in technology based on gender

	High	**Medium**	**Low**	**Total**
Male	138 (50.4%)	130 (47.4%)	6 (2.2%)	274
Female	103(45.4%)	110 (48.5%)	14(6.2%)	227

Additionally, 65%, or 329, of the student participants are aware of and very conversant with AR technology because of the daily experiences of this technology in a mobile multimedia application (Snapchat) or through a popular location-based AR game (Pokémon GO). Figure 46 demonstrates the numbers and percentage of participants who have prior knowledge of AR.

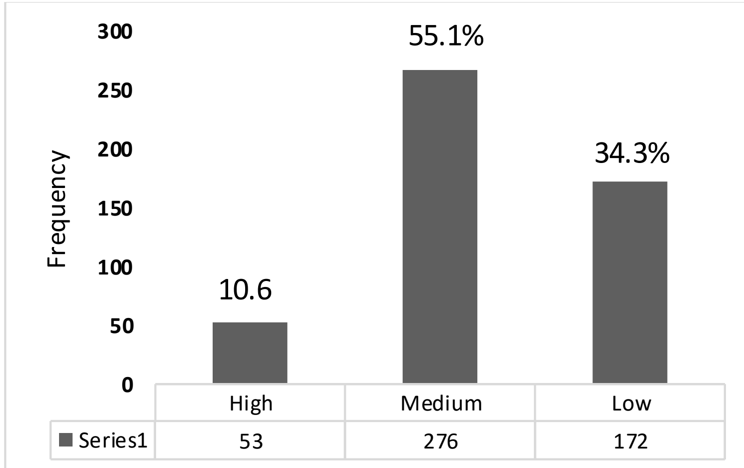


Figure 46: Students’ prior knowledge of AR

Moreover, the survey explored the extent to which students use various technological devices. This question was asked because an understanding of student trends regarding the use of such devices is essential to ensure the adoption of new technology such as AR. The results showed that a higher number of students (353) are consistently using smartphones and then laptops (244) followed by tablets (159) (please see Figure 47). The figure illustrates different kinds of devices that can be utilised when integrating AR in education as well as most of the devices that have been used by students.

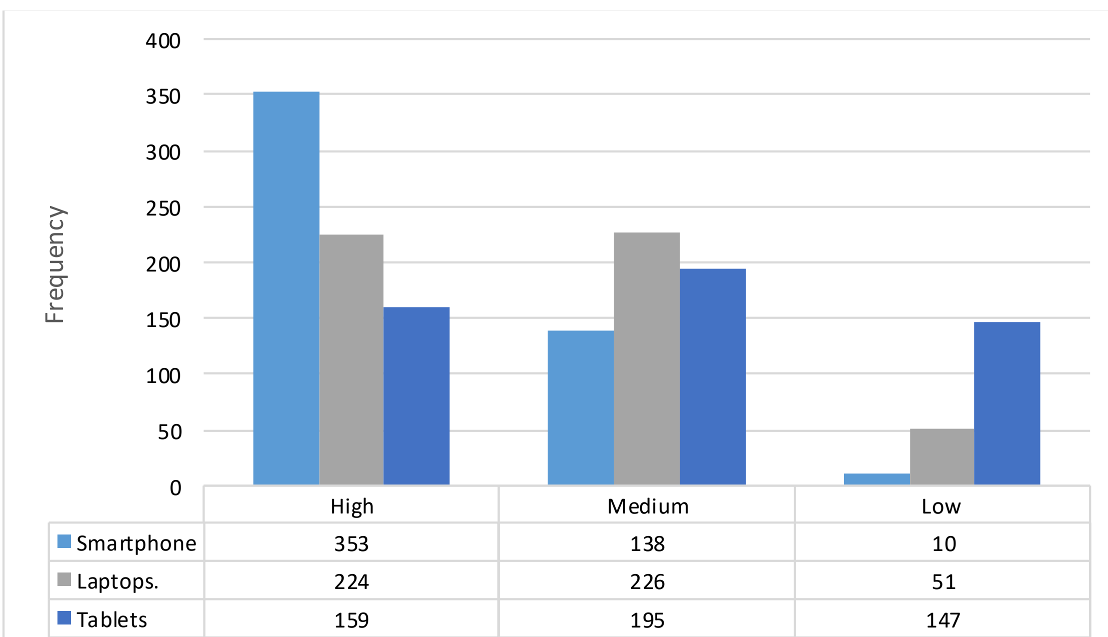


Figure 47: The level of using different devices

4.7.1.2 Descriptive Statistics for Students' Perceptions towards AR

For the question relating to the students' perceptions towards the AR method of teaching and learning, in contrast to the traditional method, participants were requested to demonstrate their agreement level by responding to 15 statements intended to identify their perception.

Participants' responses were gauged using a Likert scale of five points: 1= SD (Strongly Disagree), 2= D (Somewhat Disagree), 3= N (Neither Agree nor Disagree), 4= A (Somewhat Agree), and 5= SA (Strongly Agree). Descriptive statistics were employed to analyse the data in this section. Participants' responses were illustrated by calculating the mean of each item and standard deviations.

This study found that a higher score indicated a positive perception that students at SA universities have towards the adoption of AR technology (M=4.00, SD= 0.901). As Table 13 below shows, the most frequently revealed perceptions were statements number 4, 7, 6, and 5. Statement 4, "AR is suitable for different genders" (M= 4.25, SD= 0.875), statement 7, "AR will assist in learning and teaching" (M= 4.23, SD= 0.832), statement 6, "AR is saving time and effort for the teachers and students" (M= 4.17, SD= 0.902), and statement 5 "AR is appropriate to apply in various subjects" (M= 4.14, SD= 0.826).

The lowest frequently mentioned perception was statement number 3, "AR is suitable for different ages" (M= 3.77, SD= 1.090). Table 13 illustrates the means and standard deviations for students' perceptions towards using AR technology in the SA higher education sector.

Table 13: Descriptive statistics for items relating to student perceptions of AR

Statement	Mean[1]	Std. Deviation
1. AR is expected to achieve the intended use	3.92	0.816
2. AR is much better than traditional learning methods	4.01	0.981
3. AR is suitable for different ages	3.77	1.090
4. AR is suitable for different genders	4.25	0.875
5. AR is appropriate to apply in various subjects	4.14	0.826
6. AR saves time and effort for the teachers and students	4.17	0.902
7. AR will assist in learning and teaching	4.23	0.832
8. AR will help improve learning outcomes	3.84	0.884
9. AR meets my satisfaction and goals	3.81	0.907
10. AR will increase my learning performance	3.98	0.913
11. AR will promote self-learning	4.00	0.910
12. AR takes less time to deliver the information	3.93	0.992
13. AR as a learning tool is engaging	4.00	0.891
14. AR is a cooperative learning tool	4.00	0.861
15. AR will assist my learning efficiency	4.02	0.839
AVERAGE	4.00	0.901

4.7.1.3 Descriptive Statistics for Students' Willingness to Use AR

Students' willingness to adopt and use AR in their learning was explored. Students were asked to indicate their agreement level with six items. Students' responses were evaluated by using a Likert scale of five points: 1= SD (Strongly Disagree), D (Somewhat Disagree), 3= N (Neither Agree nor Disagree), 4= A (Somewhat Agree), and 5= SA (Strongly Agree). The means of the items and standard deviations were computed to display students' responses. As can be seen in Table 14 below, the mean score for the willingness students have towards the use of AR was positive (M=3.77, SD= 0.897). The highest frequently mentioned willingness items were numbers 3 and 5. Most students indicated that they are willing to learn more about AR technology (M=4.27, SD= 0.795) and are willing to use AR in their learning (M=4.14, SD= 0.835). Whereas the lowest frequently mentioned willingness item was number 2, "I do not want to use AR in future" (M= 3.45, SD= 1.07).

[1] The scale was: (1=SD, 2=D, 3=N, 4=A, 5=SA).

Table 14 below shows the means and standard deviations for students' willingness to use AR technology for their learning at university.

Table 14: Descriptive statistics for students' willingness to use AR

Statement	Mean[2]	Std. Deviation
1. I will use AR for learning activities	4.09	0.800
2. I do not want to use AR in future	2.05	1.115
3. I am willing to learn more about AR technology	4.27	0.795
4. I am willing to use AR in my learning	4.14	0.835
5. I like to use AR in my learning at the university	4.12	0.948
6. I will recommend to my colleagues to use AR	3.97	0.892
Average	3.77	0.897

4.7.1.4 Descriptive Statistics for Factors in the Proposed AR Framework (Students)

Descriptive statistics have been determined to ascertain how participants in the student survey answered each statement. The corresponding values of mean, median, and standard deviation for all variables of the proposed AR framework are shown in Table 15

Table 15: Descriptive statistics for each statement in students' survey

Factor	Mean	Median	Std. dev.
Usability			
AR is unnecessarily complicated	2.35	2	1.013
AR is easy to evaluate	**3.70**	**4**	**.891**
AR is easy to use	**3.72**	**4**	**.943**
Cognitive Factor			
AR requires a lot of mental effort to understand the content	2.75	3	1.081
AR will enable me to receive information quickly	**4.00**	**4**	**.859**

[2] The scale was: (1=SD, 2=D, 3=N, 4=A, 5=SA).

Factor	Mean	Median	Std. dev.
AR will help me to keep my attention on the learning task	**3.92**	**4**	**.924**
AR will help me to improve my spatial skills	**3.99**	**4**	**.892**
AR will give me a lot of pressure	2.61	3	.995
Emotional factor			
Pleasing	**4.09**	**4**	**.849**
Attractive	**4.23**	**4**	**.805**
Frustrating	1.95	2	1.005
Confusing	2.20	2	1.033
Sociocultural factor			
AR is inconsistent with the values and customs of SA	2.12	2	1.107
AR needs to be suited to the SA religious environment	**3.72**	**4**	**1.202**
AR will cause ethical concerns	2.67	3	1.218
Beliefs factor			
I want to do what most of the students think I should do concerning using AR in my learning	3.24	3	1.114
I want to do what my teachers, in particular, think I should do regarding AR using AR	**3.46**	**4**	**1.059**
People, who are important to me, would approve my using AR in my learning	**3.88**	**4**	**.917**

- ***Usability:*** Without well-designed interfaces, students might not be interested in using AR for learning purposes because of the design difficulties. The researcher used three statements to evaluate the usability of AR in education. It is apparent from Table 15 above that most students disagree that AR is unnecessarily complicated (M=2.35, SD= 1.013), whereas, students believed that AR is easy to use (M=3.72, SD= .943).
- ***Cognitive Factors:*** AR technology can require additional processing and increase the cognitive load of students, which prevents them from learning. Five statements were included to evaluate the student's opinion about this factor. As can be seen in Table 15 above, students agreed that using AR will enable them to receive information quickly (M=4.00, SD= .859); in contrast, being under

much pressure while using AR in learning was rated neutral (neither agree nor disagree) by the students' participants (M=2.61, SD= .995).

- ***Emotional factor:*** Emotion is an essential factor in teacher and learner behaviour, encouragement for learners and self-esteem (Dirkx, 2008). Four items on the questionnaire explored the effect of AR on students' emotions. In response to the first and second items, most of those surveyed indicated that AR is pleasing and attractive, M=4.09, SD= 849 and M=4.23, SD=.805 respectively (see Table 15 above). On the other hand, students disagreed that using AR is frustrating (M=1.95, SD= 1.218).
- ***Sociocultural factor:*** The institutions' context plays a role in innovation use. The researcher included three items to gauge whether Saudi social norms and culture are important factors to be considered when adopting AR. Table 15 above provides the results of the preliminary analysis of the sociocultural factor, which was rated by students as a vital factor concerning religious issues (M=3.72, SD= 1.202). Moreover, students disagreed that AR is inconsistent with the values and customs of SA. However, students were neutral (neither agree nor disagree) regarding the statement that AR will cause ethical concerns (M=2.67, SD= 1.218).
- ***Beliefs factor:*** A willingness to adopt a different approach to learning, including new technology, can also be affected by beliefs (Windschitl & Sahl, 2002). Three statements were provided to assess the influence of students' normative beliefs on the adoption of AR in universities. As can be seen from Table 15 above, most students are influenced by the opinions of their teachers and people who are important to them, M=3.46, SD=1.059 and M=3.88, SD=.917 respectively.

The survey data needed to be analysed to refine the factors that must be included in the development of an AR framework for universities in SA. The techniques used to analyse the data derived from the student survey are explained in the next section.

4.7.1.5 Students' Survey Results –EFA by Sections

To explain the structure of students' perceptions, opinion, and reactions towards AR in SA universities, EFA was applied for each section of the survey to explore the factor structure between these items.

4.7.1.5.1 AR Perceptions

Part two of the student survey was related to students' perceptions of AR. EFA was established and confirmed with a KMO value of .838 that is above .7 and a significant factor test of Bartlett $\chi^2 = 1630.015$ df = 36 ($p<.001$) (please see Table 16), factor analysis is therefore relevant in this section, and the correlations between the observed variables were mostly > 0.30. Based on the rule of eigenvalue, only those factors with a valu e greater than 1.0 are preserved (please see Table 18), by using the PCA process, two factors were extracted from 15 observed variables. Also, these factors, having eigenvalue greater than 1, are illustrated in the scree test (please see Figure 48).

To rotate the data, the Varimax method was used. Hair et al. (2010) mentioned that higher loading variables would determine factor labelling. The choice of factor labelling should also be related to the primary purpose of the factor analysis. These factors are, therefore labelled based on the items highly loaded on them and the fundamental purpose of the analysis. The EFA of the nine items under "perceptions towards AR" revealed two factors (see Table 17). Variables are loading on the first factor all related to the usefulness of AR in education. This was labelled "**perceived usefulness**". The second factor contained four observed variables related to the pedagogical contributions of AR technology to learning and teaching. It was labelled "**perceived pedagogical contributions**".

Two factors contributed 43.8% and 17.2% of the total variance, respectively (cumulative 61.1%). For ease of interpretation, Comrey and Lee (2013) and Tabachnick and Fidell (2015) suggest items should be removed due to cross-loading of .3 or above, and any factor loadings below .30 were suppressed. The Total Variance Explained, Scree plot, factor loadings, communalities, and Cronbach's α are summarised below.

STUDENTS PERCEPTIONS

Table 16: Students' perceptions of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.838**
Bartlett's Test of Sphericity	Approx. Chi-Square	1630.015
	df	36
	Sig.	**.000**

Table 17: Students' perceptions factor loadings, communalities and Cronbach's α

Rotated Component Matrix[a]	**Component**		**Communalities**
Variables	1	2	
AR is suitable for different genders	.795		.543
AR saves time and effort for the teachers and students	.785		.533
AR is suitable for different ages	.726		.464
AR assist in learning and teaching	.683		.588
AR will increase my learning performance		.822	.608
AR meets my satisfaction and goals		.797	.652
AR assists in learning efficiency		.779	.615
AR as a learning tool is engaging		.740	.583
Cronbach α	**.771**	**.820**	

Table 18: Initial eigenvalues for students' perceptions items

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.945	43.830	43.830	3.945	43.830	43.830	2.781	30.899	30.899
2	1.555	17.275	61.104	1.555	17.275	61.104	2.718	30.206	61.104
3	.727	8.074	69.178						
4	.605	6.717	75.895						
5	.553	6.140	82.035						
6	.484	5.382	87.417						
7	.446	4.956	92.373						
8	.381	4.232	96.605						
9	.306	3.395	100.000						

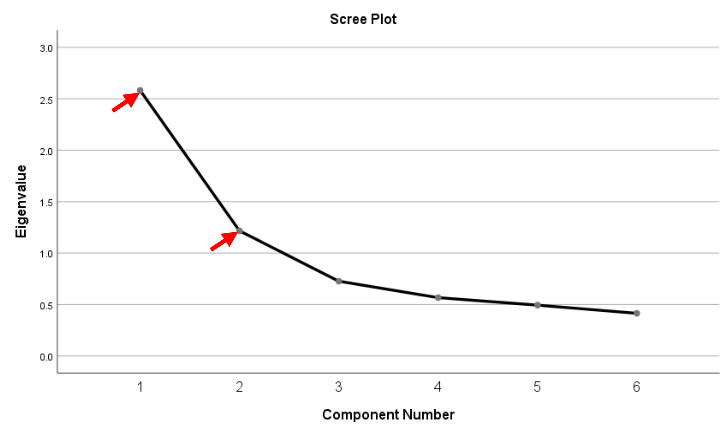


Figure 48. Scree test technique for students' perceptions items

Accordingly, out of 15 observed variables, only nine of them have high correlations among them and accounted in two factors. The minimum value was a loading factor of .683 for both components, which Comrey and Lee (1992) consider as higher loading. Both factors (perceived usefulness and AR perceived pedagogical contributions) have appropriate values of alpha coefficients of .771 and .820, confirming the internal consistency of factor items.

4.7.1.5.2 AR Technology-Related Factors and Willingness

Under this section, the researcher examined some of the factors to be taken into consideration when integrating AR into the Saudi higher education sector. The sample was factorable after conducting the Kaiser-Meyer Olkin test to measure sampling adequacy. The KMO value is .859, which is above .7, and Bartlett's test is highly significant $\chi^2 = 1857.892$ $df = 28$, $p < .000$ (please see Table 20). Therefore, factor analysis is appropriate for this section. All loadings with values less than 0.30 were suppressed in the output of analysis results. The analysis yielded two factors from eight observed variables based on the eigenvalue and the Scree test (please see Figure 49). Extracted factors were examined and labelled depending on the items that were loaded inside each factor.

The EFA of the eight observed variables under technology-related factors and adoption willingness identified two factors labelled "**AR readiness"** and '**design and usability'**, contributing 50.1%, and 15% of the total variance respectively (cumulative 66%). These two components met a specified percentage of variance, which is often 60% or greater. Items with low communalities were removed, as suggested by Pallant (2011). The Total Variance Explained, factor loadings, Communalities, and Cronbach's α are summarised in Table 19 and Table 21.

TECHNOLOGY-RELATED FACTORS AND WILLINGNESS

Table 20: KMO and Bartlett's Test for AR adoption section in students' survey

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.859**
Bartlett's Test of Sphericity	Approx. Chi-Square	1857.892
	df	28
	Sig.	.000

Table 21: Factor loadings, Communalities, and Cronbach α for AR technology-related factors and willingness section in students' survey

Rotated Component Matrix[a] Variables	**Component** 1	2	**Communalities**
Willing to use AR in my learning	.886		.814
I like to use AR in my learning at the university	.870		.779
I will use AR for learning activities	.781		.627
I will recommend to my colleagues to use AR	.774		.657
I am willing to learn more about AR technology	.743		.584
Easy to use		.881	.808
Ease to evaluate		.870	.797
Cronbach's Alpha	**.890**	**.765**	

Table 19: Total Variance Explained for AR adoption section in students' survey

Total Variance Explained

Component	Initial Eigenvalues Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings Total	% of Variance	Cumulative %	Rotation Sums of Squared Loadings Total	% of Variance	Cumulative %
1	4.077	50.964	50.964	4.077	50.964	50.964	3.534	44.177	44.177
2	1.207	15.084	66.047	1.207	15.084	66.047	1.750	21.870	66.047
3	.838	10.480	76.527						
4	.519	6.482	83.009						
5	.450	5.621	88.630						
6	.367	4.593	93.223						
7	.351	4.389	97.612						
8	.191	2.388	100.000						

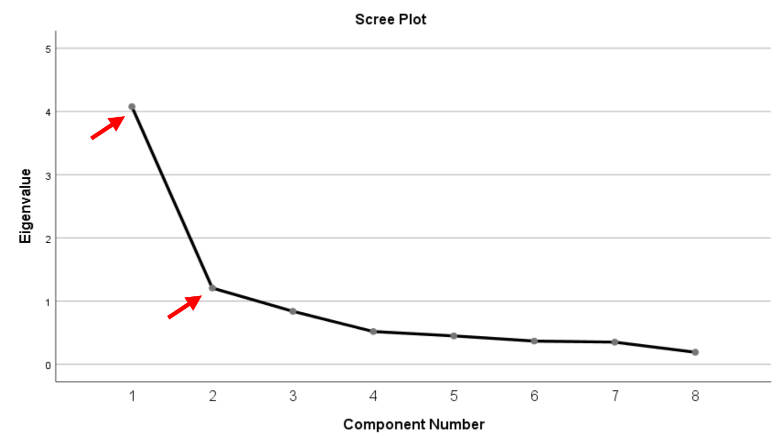


Figure 49. Scree test technique AR technology-related factors and willingness in students' survev

Consequently, the original items were reduced to seven items. Factor loadings for both factors were over 0.7, which indicates excellent correlations between the original variables and the factors. The internal consistency reliability (alpha) coefficients of the two factors items were over 0.7 (α=.890; .765 for "AR readiness" factor and "design and usability" factor, respectively). Therefore, these items scales were considered sufficiently reliable to measure students' perceptions of AR usability and their willingness to use it in higher education studies.

4.7.1.5.3 Contextual and Individuals-Related Factors

In this section, the researcher examined some of the personal related factors (cognitive and emotional effects of individuals) and contextual factors (sociocultural and beliefs) that might influence AR integration. Factor structure was determined after applying EFA using the PCA method. Furthermore, a Varimax orthogonal rotation was applied for interpretation of the factors. The Kaiser-Meyer Olkin test to measure sampling adequacy was conducted, and the sample was factorable with a KMO value of .818 and a significant $\chi^2 = 2016.542$ df = 66, $p < .000$ (please see Table 22). Therefore, factor analysis was appropriate for the data in this section. Eigenvalue and the Scree test technique recommended three factors from 12 items (please see Figure 50).

The three factors were labelled based on the observed variables encapsulated in them. The first factor clustered seven observed variables which were related to emotions and cognitions of individuals. This factor was named the **"affective and cognitive"** factor. The second factor contains variables that are related to students' normative beliefs about integrating and using AR in their learning. It was labelled **"AR norms"**. All observed variables in factor three can be regarded as social and cultural issues concerning new technology adoption in SA universities. It was labelled sociocultural factor.

The three factors contributed 34.9%, 16.3%, and 10.2% of the total variance, respectively (cumulative 60.6%). Throughout several steps, items were removed due to cross-loadings of .3 or above, and low communalities. The Total Variance Explained, factor loadings, Communalities, and Cronbach α are summarised in Table 24 and Table 23 below

CONTEXTUAL AND INDIVIDUALS-RELATED FACTORS

Table 22: KMO and Bartlett's Test for contextual and individuals related factors

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.818**
Bartlett's Test of Sphericity	Approx. Chi-Square	2016.542
	df	66
	Sig.	.000

Table 23: Factor loadings, Communalities, and Cronbach α for contextual and individuals related factors

Variables	Component 1	Component 2	Component 3	Communalities
AR as a learning tool is attractive	.794			.638
AR as a learning tool is pleasing	.773			.605
AR will help me to improve my spatial skills	.759			.591
AR will help me to remember the learning material easily	.745			.586
AR will help me to keep my attention on the learning task	.713			.569
AR as a learning tool is frustrating	.648			.496
I want to do what my teachers, in particular, think I should do regarding using AR		.875		.771
I want to do what most of the students think I should do concerning using AR in my learning		.875		.775
People, who are important to me, would approve my using AR in my learning.		.523		.508
AR will cause ethical concerns			.807	.687
AR needs to be suited to SA's religious environment			.803	.661
Cronbach's Alpha	**.842**	**.722**	**.554**	

Table 24: Total Variance Explained for contextual and individuals related factors

Total Variance Explained

Component	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %	Rotation Sums of Squared Loadings Total	Rotation Sums of Squared Loadings % of Variance	Rotation Sums of Squared Loadings Cumulative %
1	4.093	34.106	34.106	4.093	34.106	34.106	3.830	31.919	31.919
2	1.959	16.324	50.430	1.959	16.324	50.430	1.962	16.348	48.267
3	1.230	10.250	60.680	1.230	10.250	60.680	1.490	12.413	60.680
4	.911	7.591	68.271						
5	.707	5.888	74.159						
6	.600	5.002	79.162						
7	.580	4.835	83.997						
8	.493	4.108	88.105						
9	.425	3.544	91.649						
10	.364	3.036	94.685						
11	.347	2.894	97.580						
12	.290	2.420	100.000						

Extraction Method: Principal Component Analysis.

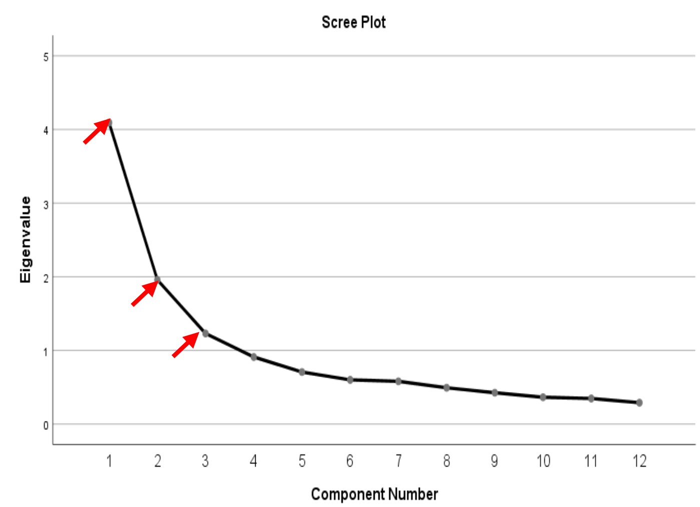


Figure 50. The Scree test technique for contextual and individuals related factors

Accordingly, the original items were reduced to 11 items. Cronbach's α was used to assess the internal consistency of the items when establishing a factor. The Cronbach' Alpha values for first and second factors exceeded 0.7 (α= .842 and .722 for the affective and cognitive factor, and the AR norm factor, respectively), whereas the third factor had low internal consistency reliability (alpha) coefficients with a value of .554. The rest of these factor items were considered to be sufficiently reliable to measure students' opinions regarding AR affective, cognitive and normative beliefs factors.

4.7.1.5.4 The Retained Factors (Students' Survey Section Analysis)

The researcher generated EFA for the students' surveys by sections or themes to assess scale validity and find if there were any significant differences between the findings. Based on EFA by sections, six factors were identified, and labelled from the students survey sections analysis: (1) perceived usefulness; (2) perceived pedagogical contributions; (3) AR readiness; (4) design and usability; (5) affective and cognitive factor; and (6) AR norm. Cronbach's alpha values for six improved factors in the student survey section are shown in Table 25 below. Besides, concept maps were generated in section 4.7.1.9 to enable the comparison of the results derived from both analysis techniques of students survey. Figure 53 illustrates the students' outcomes from the survey sections analysis as a concept map.

Table 25: The factors retained from students' survey sections analysis

Factor	*N* of items	Name (Label)	Cronbach's Alpha
1	4	Perceived usefulness	**.771**
2	4	Perceived pedagogical contributions	**.820**
3	5	AR readiness	**.890**
4	2	Design and usability	**.765**
5	6	Affective and cognitive factor	**.842**
6	3	AR norm	**.722**

4.7.1.6 Students' Survey Results – Whole Survey EFA

This section presents the findings for the student survey after generating EFA for the whole survey. The findings from this analysis technique were compared with previous analysis (sectional analysis), and changes were made accordingly. These methods help the researcher to ensure that observed variables are gauging that construct and confirm the scale validity. EFA was created and affirmed factorability with a subject to KMO value of .900, which is above .6, and Bartlett's test confirmed the significance $\chi^2 = 5316.216$ df = 253, $p < .000$ (please see Table 26), the communalities were all above .3, further justifying that each variable shared some common variance with other variables and, factor analysis was, therefore, appropriate for this study.

Based on the eigenvalue rule, whereby only factors with an eigenvalue greater than 1.0 are retained, six factors were recorded from 23 observed variables of the students' survey under the main factors that impact incorporating AR in higher education in SA universities by using PCA method. Six components recorded eigenvalues above 1.0 (8.045, 1.924, 1.753, 1.337, 1.122, and 1.001), explaining a total of variance 65% (please see Table 27). Also, the Scree test and Kaiser's criterion (the eigenvalue rule), which is greater than 1.0, were utilised to help to identify a meaningful and accurate list of factors (please see Figure 51).

After the number of factors was determined, the next step was to obtain a more straightforward and meaningful factor solution using the rotation method. To rotate the data, the Varimax method was used. The reason for selecting the rotation method was explained earlier in section 4.6.5. Interpreting the data in this survey analysis was executed by selecting sorted by size and suppress small coefficients options in the coefficient display format. The results of an orthogonal rotation of the solution, communalities, and Cronbach's α are shown in Table 28. When loadings were less than 0.30, they were excluded for more straightforward interpretation.

The Total Variance Explained, Scree plot, factor loadings, communalities, and Cronbach's α are summarised below.

STUDENTS WHOLE SURVEY ANALYSIS SUMMARY

Table 26: Student whole survey KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.900**
Bartlett's Test of Sphericity	Approx. Chi-Square	**5316.216**
	df	**253**
	Sig.	**.000**

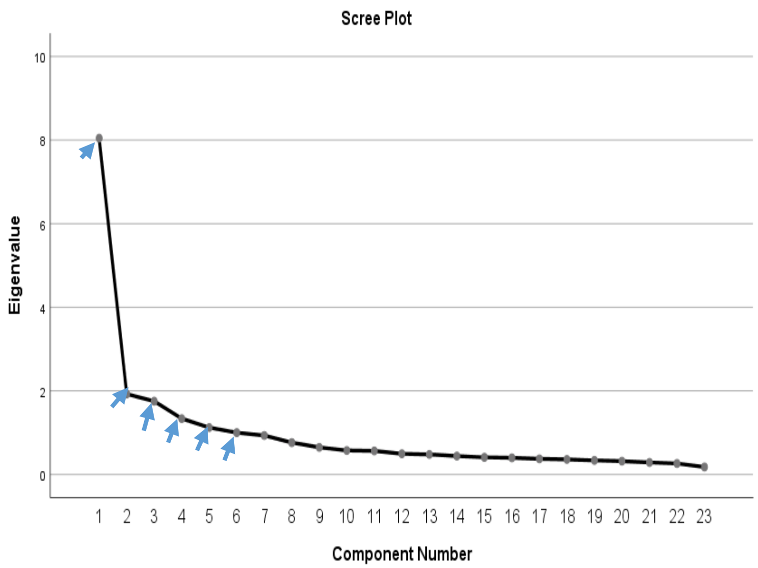


Figure 51. The Scree test results for the entire student survey

Table 27: Total Variance Explained and eigenvalue for Student whole survey

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.045	34.977	34.977	8.045	34.977	34.977	3.649	15.864	15.864
2	1.924	8.366	43.343	1.924	8.366	43.343	3.067	13.335	29.199
3	1.753	7.620	50.963	1.753	7.620	50.963	2.612	11.356	40.554
4	1.337	5.812	56.775	1.337	5.812	56.775	2.127	9.249	49.803
5	1.122	4.877	61.652	1.122	4.877	61.652	2.102	9.138	58.941
6	1.001	4.351	66.003	1.001	4.351	66.003	1.624	7.062	66.003
7	.932	4.054	70.057						
8	.762	3.314	73.371						
9	.648	2.817	76.188						
10	.573	2.492	78.679						
11	.564	2.452	81.132						
12	.495	2.152	83.284						
13	.479	2.084	85.368						
14	.440	1.913	87.281						
15	.410	1.784	89.065						
16	.398	1.730	90.794						
17	.373	1.623	92.417						
18	.360	1.565	93.983						
19	.337	1.465	95.448						
20	.318	1.383	96.830						
21	.287	1.250	98.080						
22	.263	1.144	99.224						
23	.179	.776	100.000						

Table 28: Factor loading, communalities, and Cronbach's α for the entire student survey

Factor Label	Variable	Component 1	2	3	4	5	6	Communalities
AR readiness	Willing to use AR in my learning	.816						.816
	I like to use AR in my learning at the university	.790						.776
	I will recommend to my colleagues to use AR	.728						.684
	I will use AR for learning activities	.720						.656
	I am willing to learn more about AR technology	.718						.606
Affective and cognitive factor	AR as a learning tool is frustrating		.779					.676
	AR as a learning tool is confusing		.725					.620
	AR will help me to improve my spatial skills		.595					.567
	AR will help me to remember the learning material easily		.595					.587
	AR will help me to keep my attention on the learning task		.548					.557
	AR as a learning tool is attractive		.536					.587
Perceived usefulness	AR is suitable for different genders			.820				.699
	AR is saving time and effort for the teachers and students			.753				.629
	AR is suitable for different ages			.717				.561
	AR will assist in learning and teaching			.621				.586
AR norm	I want to do what most of the students think I should do concerning using AR in my learning				.854			.745
	I want to do what my teachers, in particular, think I should do regarding using AR				.852			.756
	People, who are important to me, would approve my using AR in my learning.				.512			.487
Pedagogical contributions	AR is taking less time to deliver the information					.796		.715
	AR as a learning tool is engaging					.717		.661
	AR will assist my learning efficiency					.599		.609
design and usability	Ease to evaluate						.837	.805
	Easy to use						.837	.795
Number of test measures		**5**	**6**	**4**	**3**	**3**	**2**	
Alpha Reliability α		**.890**	**.823**	**.771**	**.722**	**.724**	**.756**	

Rotated Component Matrix[a]

Significant loading items on each component allow the researcher to assign a valid name representing the loaded variables of that factor. The significant variables were scrutinised to label factors as accurately as possible. In the next section, the improved extracted factors are summarised.

4.7.1.7 The Students' Six Topic Factors and Reliability (Whole Survey)

As mention previously, due to a low internal consistency (alpha) value for the social factor scale, sociocultural items were excluded from the analysis of the student survey. Accordingly, the internal consistency (alpha) coefficients of the six factors were .890, .823, .711, .722, .724, and .756 respectively. Also, Cronbach's alpha for all 23 items was .908.

Five observed variables were loaded onto factor one. As can be seen from Table 28 above, these five observed variables are strongly related to students' readiness to use AR in their learning activities and desire to learn more about this technology. The first item focused on the willingness of students to use AR in learning. Following this, the second item reflected how students like to use AR technology. The third item focused on students' willingness to recommend AR to their colleagues. In item four, the willingness of students to learn more about AR technology is reaffirmed. The fifth item focused on students' readiness to use AR in activities related to learning. Therefore, this factor was labelled "**AR readiness**".

Factor two clustered six observed variables related to the emotional and cognitive effects of individuals when using AR in learning. The first and second variables related to students' feelings when they engaged with AR as a learning method. These two items focused mainly on students' frustration and confusion. Similarly, the third, fourth, and fifth variables reflected the cognitive effect when students use AR technology in their learning, such as improving their spatial skills, memory and attention. Variable six focused on the attraction of AR as a learning method, and therefore, this factor was labelled "**affective and cognitive factor**".

Four observed variables loaded onto a third factor related to the usefulness of AR technology in higher education. The first item reflected the usefulness of the AR method in saving time and effort for the teachers and students. Following this, items two and three focused on the suitability of AR technology for different age groups and genders. The fourth item reflected the usefulness of AR as a supplementary tool for learning and teaching. This was named “**perceived usefulness**”.

Items loaded for factor four related to students’ normative beliefs concerning using AR in learning. These three variables focused on the influence of peers, teachers and family on the students’ perceptions of AR technology as a learning and teaching tool in universities. This was labelled “**AR norm**”.

Factor five observed variables related to the importance of using AR for pedagogical purposes in higher education. These items reflected the contributions of AR to pedagogy. These variables were related to the pedagogical potential of AR in taking less time to deliver the information to the students, being used as a tool to improve student engagement, and improving learning efficiency. Thus, this factor was labelled “**AR pedagogical contributions**”.

Factor six consisted of two observed variables. These two variables focused mainly on the usability of the technology. Students reported the ease of using AR technology in education. Therefore, this factor was called “**design and usability**”.

The factors’ labels and the results of the reliability test are presented in Table 29 below. Also, Figure 54 demonstrates the outcomes of whole student survey analysis as a concept map.

Cronbach's alpha for all 23 items	N of Items
.904	23

Table 29: AR factors and reliability from the whole student survey

Factor	N of items	Name (Label)	Alpha Reliability α
1	5	AR readiness	**.890**
2	6	Affective and cognitive factors	**.823**
3	4	Perceived usefulness	**.805**
4	3	Perceived pedagogical contributions	**.724**
5	3	AR Norm	**.722**
6	2	Design and Usability	**.756**

4.7.1.8 Students' Comments Analysis

As mentioned previously in the survey design section, the survey included open questions to ensure content validity by inviting students to express their opinion about the integration of AR in SA universities. Students were excited about AR in education as they find it to be a solution for promoting self-learning and making theoretical curricula more realistic. However, some students believe they are not yet able to use AR technology in their learning and teaching and prefer not to depend entirely on AR but to have an instructor as their primary source of information.

Furthermore, student participants were invited to make comments on other factors that might facilitate or influence the integration of AR in universities. A word cloud is a tool that can be utilised for visualising text data. To analyse students' comments, a word cloud analysis was generated via NVivo 12 to help the researcher to assess the textual input from the participants and identify words that appeared the most frequently in their comments. Also, it helped the researcher to explore some factors that were not covered by the questionnaire.

The result indicated that the students believed that AR as a learning tool would be useful, enjoyable and fun. However, several other factors were identified in the students' responses. The results of the text analysis showed that some students believed that integrating AR technology in SA universities needs training and support. As shown in Figure 52 below, some of the most frequently occurring words are related to AR cost.

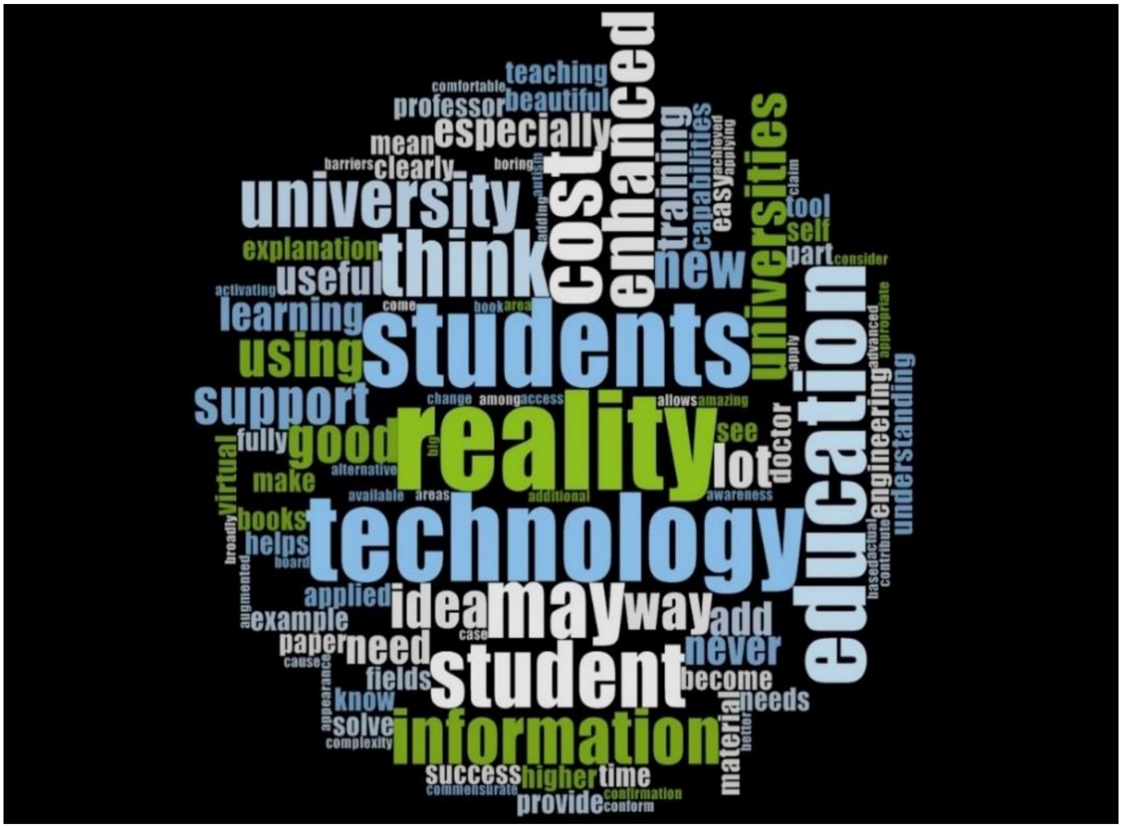


Figure 52: Students' word cloud analysis

4.7.1.9 Student Findings Concept Maps

A concept map was generated to organise and represent the students' survey findings after applying EFA by two analysis techniques. Figure 53 and Figure 54 below demonstrate the factors' items and factor loadings from both approaches.

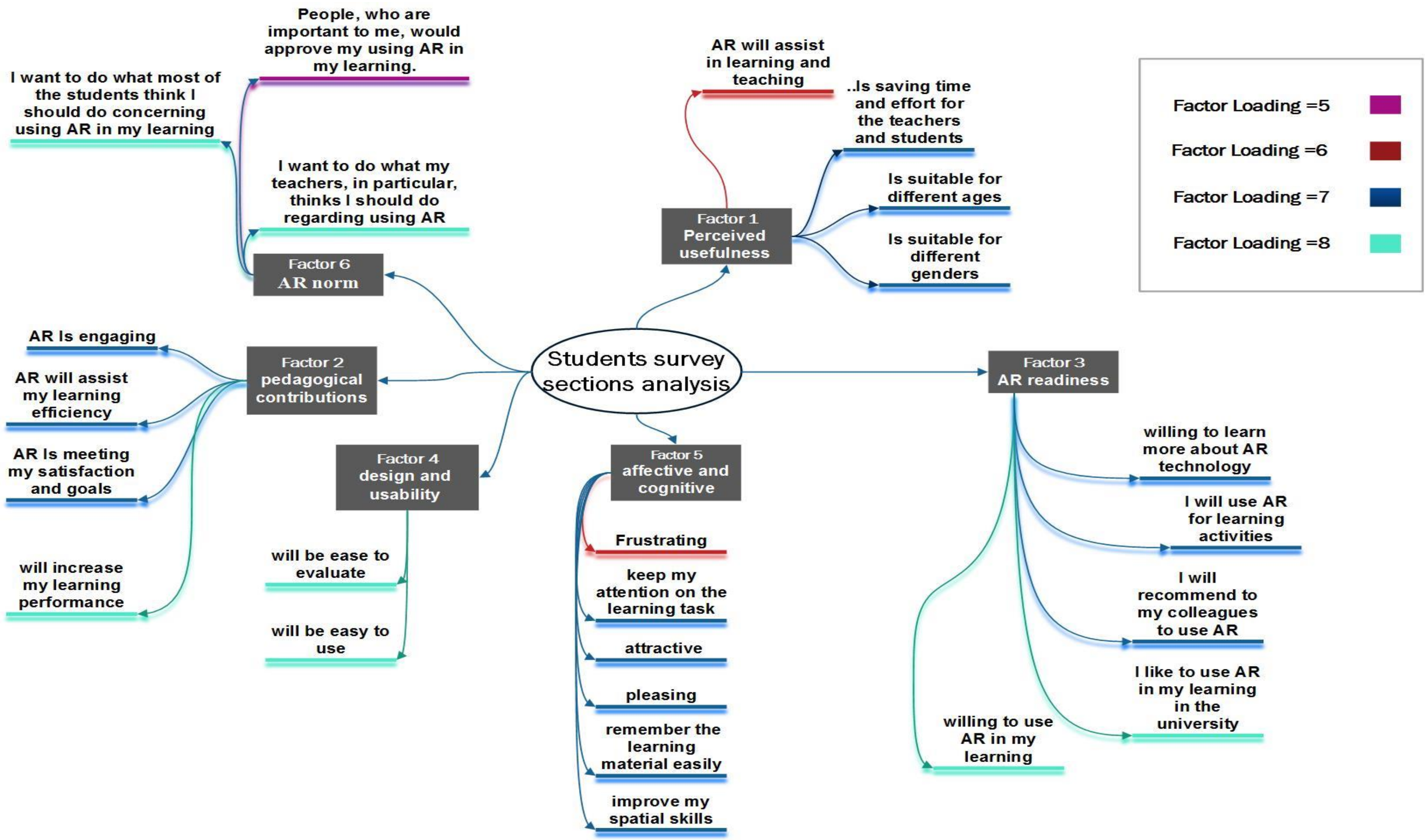


Figure 53: Concept maps illustrating students’ findings from survey sections analysis

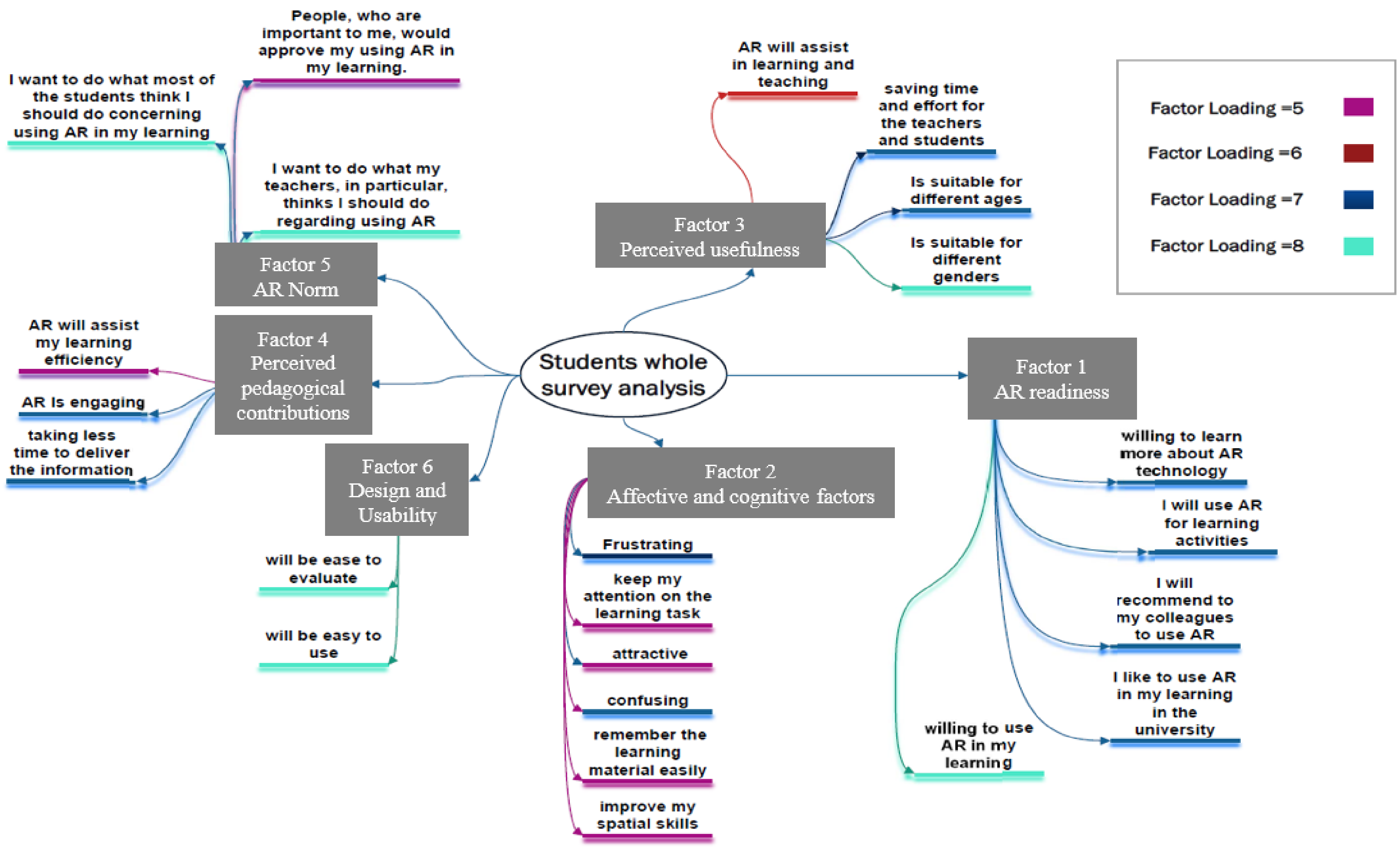


Figure 54: Concept maps illustrating Students' findings from student whole survey analysis

4.7.1.10 Summary of Students' Online Survey Outcomes

This section discusses the survey conducted using students in SA universities to discover the factors that must be included when developing an AR framework for higher education in SA. The 501 subjects were recruited using a hyperlink via the Qualtrics survey software. The demographic profile of students was illustrated. Results indicate that the majority (84%) of SA university students reported a satisfactory level of computer experience. Furthermore, students reported a high ranking of interest in technology. The smartphone was the device preferred by students in SA universities, followed by laptops and then tablets. Furthermore, 65% of the total student participants are aware of and well-informed about AR technology.

EFA was used for the remaining survey data. Two EFA techniques were applied to establish the validity and reliability of the survey data. These included the analysis of students' survey by sections as well as EFA for the whole survey. Six factors related to the students' survey were retained after applying both techniques. The findings from both approaches did not show significant differences, which implies that both sectional EFA and whole-survey EFA tended to have similar findings regarding the factors (please see Table 25 and Table 29). This indicates that the factors were well measured by their indicators. Only a few items were eliminated in the analysis of the sections, and three were added in the second approach (whole-survey analysis) as presented in Figure 53 and Figure 54. Thus, all factors and items resulted from both analyses were added to the revised framework.

Cronbach's α generated internal consistency with values exceeding 0.7, ranging from .756 to.890. The survey data analysis explained why several observed variables had to be excluded from the analysis and the initial framework because they did not contribute to a simple factor structure and were unable to meet the minimum criteria (low factor loadings, low communalities or low Cronbach's α value). Thus, the validity and reliability of the developed scales were confirmed. The findings from the student survey were then discussed. In the next section, the academic and e-learning staff surveys are analysed using the same strategies that were used for the analysis of the student surveys. The findings from the academic and e-learning staff survey are then merged with students' results and added to the AR framework for SA.

4.7.2 Academic and E-Learning Staff Online Survey

In the following subsections, staff online survey analysis and findings are presented. This includes demographic information, descriptive analysis and EFA analysis.

4.7.2.1 Demographic Analysis

The participants were 146 academics and 82 e-learning department employees. The majority of academic respondents (89, or 61%) were male, while the number of female respondents was 57, or 39%. More than half (54.9%) of all e-learning staff were male, while the number of e-learning staff that were female was 37, or 45.1%. The demographics for the staff sample are summarised in Table 30.

Table 30: Staff Demographics

Job Title	**Gender**		
	Male	Female	Total
Lecturers and academic members	89 (61%)	57 (39%)	146
E-learning department staff	45 (54.9%)	37 (45.1%)	82

In comparison, most academic (lecturers) participants (47, or 32.2%) were between the ages of 34 and 38 years old. Around 12, or 8.2 % of academics were between 24 and 28 years of age. There were 29 lecturers in the 29-33-year age group. Of the 146 respondents, 34 (23.3%) were in the 39 to 44 age group. Only 22 lecturers were over the age of 45 years. Table 31 below presents the ages of the academic and lecturers' sample.

Table 31: Ages of lecturers and academics

Category	Frequency	Percentage
18–23	2	1.40%
24–28	12	8.20%
29–33	29	19.90%
34–38	47	32.20%
39–44	34	23.30%
45–50	11	7.50%
50 and above	11	7.50%
Total	**146**	**100**

As already indicated, the total number of participants in e-learning departments was 82. Most of the e-learning participants (36.6 %) were between 34 and 38 years of age. Nine respondents were between the ages of 24 and 28, followed by those 29 and 33 years (28 %). Sixteen participants from e-learning departments were aged from 39 to 44, and just 4.9% of e-learning staff were between 45 and 50. The ages of e-learning staff are shown below in Table 32.

Table 32: E-learning departments' staff ages

Category	Frequency	Percent
24–28	9	11.0%
29–33	23	28.0%
34–38	30	36.6%
39–44	16	19.5%
45–50	4	4.9%
Total	**82**	**100.0**

Regarding the education level of academic and e-learning staff, 43.4% had a master's degree, 35.1% were qualified with a doctorate,17.1% had a bachelors qualification, 3.9% held a postgraduate diploma, and only one of the participants had a diploma qualification. Figure 55 below provides a summary of responses regarding participants' level of education.

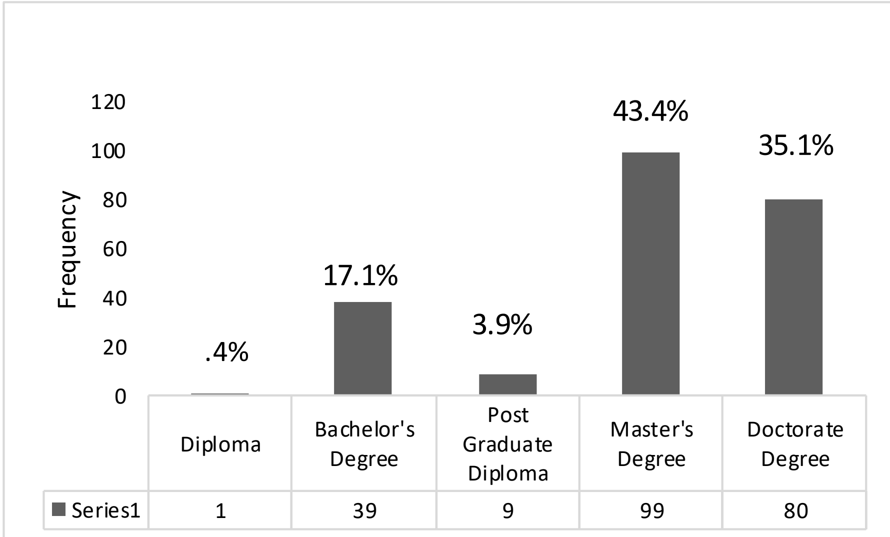


Figure 55: Staff education level

Academics and lecturers were asked to demonstrate to what degree they used technology in professional activities. The outcomes illustrated that most respondents (95.2%) of both genders had a medium-to-high rate of teaching and learning technology usage, while only 4.8 per cent had a low use of technology in their professional activities. Table 33 below indicates how often academic staff use technology in education.

Table 33: Academic educational usage of technology

Level	Frequency	Percent
High	84	57.5%
Medium	55	37.7%
Low	7	4.8%
Total	**146**	**100.0**

Lecturers and e-learning staff participants were asked to reveal their proficiency in using a computer. Just under half (49%) reported that they are advanced in using computers. 32.9 % of academic and e-learning participants are expert in dealing with the computer. A minority of participants (1.3%) indicated that they are beginners. Overall, these results indicated that most of the academic and e-learning staff have an adequate level of computer experience. Table 34 below presents the summary statistics for the staff’s computer experience level.

Table 34: Staff's computer experience level

Level	Frequency	Percent	Valid Percent	Cumulative Percent
Beginner	3	1.3%	1.3	1.3
Intermediate	38	16.7%	16.7	18.0
Advanced	112	49.1%	49.1	67.1
Expert	75	32.9%	32.9	100.0
Total	**228**	**100.0**	**100.0**	

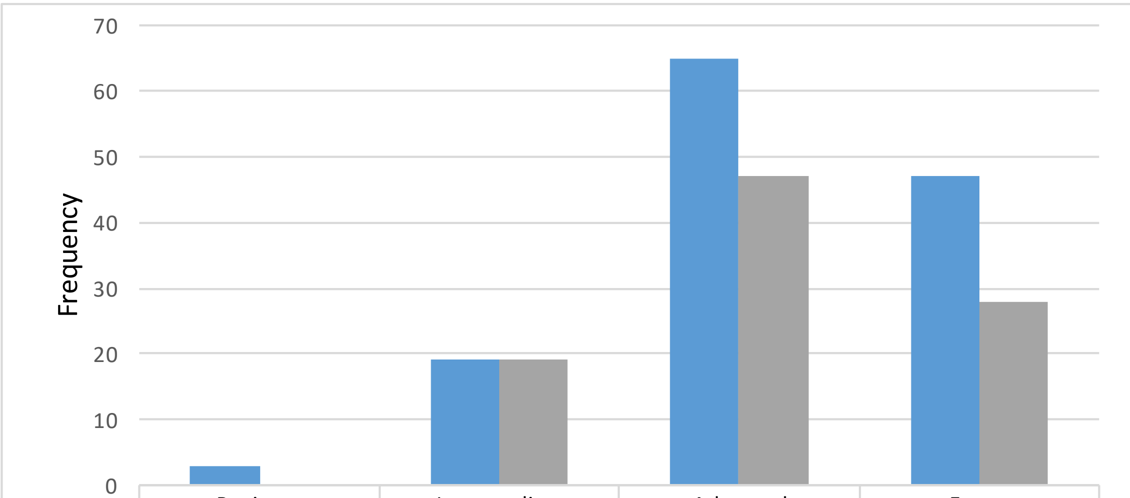
Regarding computer proficiency across the age groups of academic and e-learning participants, as can be seen from the table below, the 34–38 age group reported a more considerable computer experience more than the other groups with 33.8%. Additionally, an advanced level of computer experience is the highest in each age group except for the 45–50 age group. Table 35 shows the level of academic and e-learning computer experience based on participants' age.

Table 35: Staff computer experience level based on age

		Computer Experience Level				Total
		Beginner	Intermediate	Advanced	Expert	
age	18–23	0	0	2	0	2
		0.0%	0.0%	1.8%	0.0%	0.9%
	24–28	0	1	15	5	21
		0.0%	2.6%	13.4%	6.7%	9.2%
	29–33	0	9	26	17	52
		0.0%	23.7%	23.2%	22.7%	22.8%
	34–38	0	12	36	29	77
		0.0%	31.6%	32.1%	38.7%	33.8%
	39–44	0	6	24	20	50
		0.0%	15.8%	21.4%	26.7%	21.9%
	45–50	1	7	5	2	15
		33.3%	18.4%	4.5%	2.7%	6.6%
	50 and above	2	3	4	2	11
		66.7%	7.9%	3.6%	2.7%	4.8%
Total		3	38	112	75	228
						100.0%

Both female and male staff reported similar levels of considerable experience with computers. 48.5% of male participants had an advanced level of computer experience, while 50.0% of female participants were advanced in using the computer.

From the data in Figure 56, it is apparent that only three male participants considered themselves as beginners in the computer, whereas no female participants were still at the beginner level. The findings of the preliminary analysis of staff experience in using the computer-based on their age are presented in Figure 56 below.



	Beginner	Intermediate	Advanced	Expert
Male	3	19	65	47
Female	0	19	47	28

Figure 56: Staff computer experience level based on gender

As can be seen from the graph in Figure 57, almost two-thirds of the academic and e-learning participants (73%), comprising both genders, showed a high level of interest in technology. A minority of participants (0.9%) had a low level of technology interest. The table below illustrates staff data regarding interest in technology.

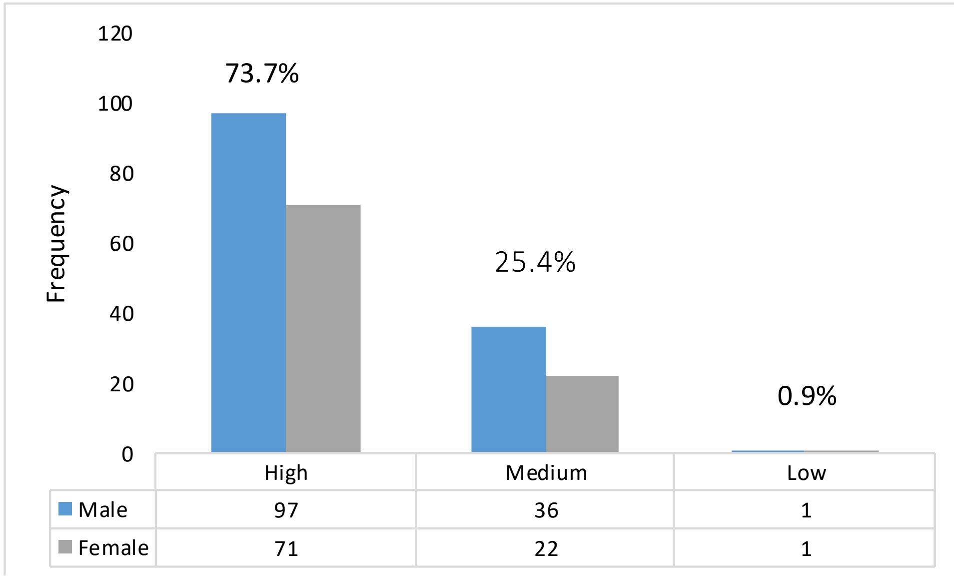


Figure 57: Academic interest in technology

Academic and e-learning staff were requested to show their knowledge of AR and its use in education. Based on the gender, (73.9%, or 99 participants) of the total male sample of lecturers and e-learning staff (134) were familiar with the concept of using AR technology in education and were ready to adopt it, while (84%, or 79) of the total female sample of lecturers and e-learning participants (94) were well-informed about AR technology and had used it previously. Thus, this sample was considered qualified to give an opinion that could contribute to the accuracy of this study's findings. Participants' gender and their knowledge of AR is shown in Table 36 below.

Table 36: Academic and e-learning prior knowledge about AR based on gender

			Prior knowledge of AR			**Total**
			High	**Medium**	**Low**	
Gender	**Male**	**Count**	32	67	35	134
		% within Gender	23.9%	50.0%	26.1%	100.0%
	Female	**Count**	18	61	15	94
		% within Gender	19.1%	64.9%	16.0%	100.0%

4.7.2.2 Descriptive Statistics for Academic and E-Learning Staff Perceptions towards AR

E-learning and academic staff perceptions were also measured to answer research question two. They were asked to evaluate their agreement level with 18 statements. To measure perceptions, a Likert scale of five points was applied: 1= SD (Strongly Disagree), 2= D (Somewhat Disagree), 3= N (Neither Agree nor Disagree), 4= A (Somewhat Agree), and 5= SA (Strongly Agree). Statistical analysis of the results was conducted by measuring the statement means and standard deviations to demonstrate the participants' responses. The general perceived use of AR in SA universities by academics and e-learning staff was strong (M=4.07, SD= 0.87). The most often reported perceptions were numbers 14, 8, 15, 7, 18, and 16, as can be seen in Table 37 below. Item 14, "AR is a motivating learning method" (M= 4.39, SD= 0.798), item 8, "AR is attractive" (M= 4.35, SD=0.785), item 7, "AR is exciting" (M= 4.32, SD= 0.802), item 18, "AR is enjoyable" (M= 4.31, SD= 0.836), and item 16, "AR will promote self-learning" (M= 4.30, SD= 0.875).

The lowest frequently indicated perceptions were items number 5 and 6. Item 5, "AR is appropriate to apply in various subjects" (M= 3.62, SD= 1.12), and item 6, "AR is considering the individual differences among students" (M= 3.73, SD= 0.921). The findings from the preliminary analysis of academics and e-learning staff perceptions towards the adoption of AR technology by SA Universities are summarised in Table 37 below.

Table 37: Descriptive statistics for staff perceptions

Statement	Mean[3]	Std. Deviation
1. AR is expected to achieve the intended use	3.86	0.786
2. AR is much better than traditional learning methods	3.84	0.982
3. AR is suitable for different ages	3.92	0.926
4. AR is suitable for different genders	4.07	0.948
5. AR is appropriate to apply in various subjects	3.62	1.12
6. AR is considering the individual differences among students	3.73	0.921
7. AR is exciting	4.32	0.802
8. AR is attractive	4.35	0.785

[3] The scale was: (1=SD, 2=D, 3=N, 4=A, 5=SA).

Statement	Mean[3]	Std. Deviation
9. AR will allow me to do things that I cannot easily do now	3.84	0.911
10. AR is useful	4.18	0.833
11. AR saves time and effort for the teachers and students	3.96	0.921
12. AR will help to improve learning outcomes	4.04	0.804
13. AR facilitates learning and teaching	4.18	0.835
14. AR is a motivating learning method	4.39	0.798
15. AR is more interesting	4.32	0.779
16. AR will promote self-learning	4.30	0.875
17. AR is a cooperative learning tool	4.08	0.889
18. AR is enjoyable	4.31	0.836
Average	**4.07**	**0.87**

4.7.2.3 Descriptive Statistics for E-Learning and Academic Members' Willingness to Integrate AR

The researcher included six statements to evaluate academic and e-learning staff willingness to adopt AR in their teaching. Participants were asked to indicate their level of agreement with these statements. For the calculation of perceptions, a Likert scale of five points was again utilised: 1= SD (Strongly Disagree), 2= D (Somewhat Disagree), 3= N (Neither Agree nor Disagree), 4= A (Somewhat Agree), and 5= SA (Strongly Agree).

Descriptive statistics were used to examine the data in this section by computing the means of the items and standard deviations to show participants' responses. The results, as shown in Table 38 below, indicate the significant positive willingness of academic members and e-learning staff to adopt AR in teaching (M=4.20, SD= 0.778).

It can be seen from the data in Table 38 below that the willingness responses with the highest frequencies were numbers 2 and 4. Item 2 was "I am willing to learn more about AR technology" (M= 4.37, SD= 0.718), and item 4 was "AR should be introduced in my university" (M= 4.33, SD= 0.786). Table 38 below shows the means and standard deviations for academic members and e-learning staff willingness to use AR technology in their teaching at universities.

Table 38: Descriptive statistics for staff willingness to integrate AR

Statement	Mean[4]	Std. Deviation
1. I am willing to use AR for activities concerning the teaching of course materials	4.25	0.819
2. I am willing to learn more about AR technology	4.37	0.718
3. I am willing to use AR in my teaching and professional activities	4.32	0.727
4. AR should be introduced in my university	4.33	0.786
5. AR learning tools are the best choice for teaching my subject area	3.81	0.893
6. I will recommend to my colleagues to use AR	4.11	0.728
Average	**4.20**	**0.778**

4.7.2.4 Descriptive Statistics of Factors of the Proposed AR Framework (Academic Members)

Descriptive statistics were calculated regarding participants' responses to each statement in the staff survey. The corresponding values of mean, median, and standard deviation for all variables of the proposed AR framework are shown in Table 39 below.

[4] The scale was: (1=SD, 2=D, 3=N, 4=A, 5=SA).

Table 39: Descriptive statistics for each factor from the staff survey

Factor	Mean	Median	Std. dev.
Usability			
AR is unnecessarily complicated	2.39	2	1.112
AR is easy to evaluate	**3.81**	**4**	**.950**
AR is easy to use	**3.61**	**4**	**.871**
Universities related factors			
Students' acceptance of AR technology.	**3.87**	**4**	**.939**
Faculty members and staff acceptance of AR technology.	**3.92**	**4**	**1.014**
Funding by the government.	**4.29**	**4**	**.848**
High-speed internet connectivity.	**4.56**	**5**	**.734**
Sufficient hardware.	**4.53**	**5**	**.748**
Sufficient software.	**4.57**	**5**	**.702**
Technical support and maintenance.	**4.57**	**5**	**.714**
AR training.	**4.53**	**5**	**.705**
Testing AR systems.	**4.54**	**5**	**.685**
AR evaluation.	**4.46**	**5**	**.770**
Sociocultural factor			
AR is inconsistent with the values and customs of SA.	2.13	2	1.099
AR needs to be suited to the SAn religious environment.	**3.33**	**4**	**1.345**
AR will cause ethical concerns.	2.52	2	1.097
Beliefs factor			
I want to do what most of my lecturers and professors think I should do concerning using AR in my learning.	3.25	4	1.160
I want to do what my university head department and dean, in particular, think I should do regarding using AR.	**3.63**	**4**	**1.052**
People, who are important to me, would approve my using AR in my work.	**3.96**	**4**	**.747**

- ***Usability:*** The researcher provided three items to measure e-learning and academic staff opinion regarding the usability of AR. It can be seen from the data in Table 39 above that AR was highly rated as easy to evaluate and use, M= 3.81, SD= .950 and M= 3.61, SD= .871, respectively.

- ***Universities related factors (support and infrastructure):*** Weak infrastructure and poor support create a reluctance among teachers and students to use the systems and available services (Altameem, 2013). Ten items were used regarding infrastructure and support to evaluate whether they could be considered as essential items contributing to or preventing AR integration. The results, in Table 39 above, show the e-learning and academic staff agreed that most of the included items are essential.

- ***Sociocultural factor:*** Three statements were designed to evaluate e-learning and academic staff opinions on the importance of social and cultural factors to the integration of AR in Saudi universities. From the table above, it can be seen that most responses regarded accommodating the SA religious environment as necessary and could influence the adoption of AR in SA education (M= 3.33, SD= 1.345). On the other hand, participants disagreed with the other statements.

- ***Beliefs factor:*** to identify the influence of normative beliefs on academic members, three statements were provided. As shown in Table 39 above, most of the academic members' perceptions to integrating AR was influenced by the people who are important to them, and by university department heads and deans of faculties, M= 3.96, SD= .747 and M= 3.63, SD= 1.052 respectively. In the next subsection, the EFA is applied to the e-learning and academic staff survey and demonstrated in more detail.

4.7.2.5 E-learning staff And Academic survey results – EFA by sections

For each section of the academic and e-learning staff survey, EFA analysis was also carried out to explore the variable structure between academic surveys items and guarantee an excellent structural validity.

4.7.2.5.1 AR Perceptions

EFA was performed for the 18 structure items under staff perceptions towards AR in higher education, using the PCA and Varimax rotational methods. Favourable subjects confirmed the factorability of the structure items. The Kaiser-Meyer-Olkin measure of sampling adequacy was KMO .931, above the suggested value of .6; Bartlett's Test of Sphericity was significant χ^2 = 1789.918 df = 78, $p < .000$ (please see Table 40). All loadings less than 0.40 were suppressed in the output. As shown in Figure 58, two factors were identified from both the eigenvalues and the scree plot. The eigenvalues indicated that the first factor explained 51.9% of the variance, the second factor 9.7% of the variance. The total variance of factors was 61.6%. Factor 1 comprises observed variables related to the pedagogical potential of AR in teaching and learning practices. This factor was labelled "**Perceived pedagogical contributions**".

Items loaded onto factor two reflected the usefulness of AR in a higher education context. It was named "**Perceived usefulness**". As a result, the original 18items were reduced to 13 items. The minimum highest value was a factor loading of .575 for both factors. All scales had acceptable reliability coefficients (Nunnally & Bernstein, 1994). Both factors (perceived AR pedagogical contributions and perceived usefulness) had a Cronbach's alpha of .923 and .772, respectively, thereby confirming the internal consistency reliability of factor items. The total variance explained factor loadings, communalities, and Cronbach's α are summarised below in Table 42 and Table 41.

STAFF PERCEPTIONS

Table 40: KMO and Bartlett's Test for staff perceptions items

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.931**
Bartlett's Test of Sphericity	Approx. Chi-Square	1789.918
	df	78
	Sig.	.000

Table 41: Staff perceptions section factor loadings, communalities, and Cronbach's α

Rotated Component Matrix[a]			Communalities
Variables	Component 1	Component 2	
AR is exciting	.897		.850
AR is attractive	.866		.818
AR is more interesting	.826		.740
AR is enjoyable	.824		.743
AR is a motivating learning method	.722		.695
AR will promote self-learning	.686		.518
AR helps to improve learning outcome	.623		.576
AR is a cooperative learning tool	.575		.419
AR is suitable to apply in various subjects		.770	.601
AR will allow me to do things that I cannot easily do now.		.675	.543
AR is saving time and effort for the teachers and students		.666	.590
AR is much better than traditional learning methods		.643	.495
AR is expected to achieve the intended use		.613	.427
Cronbach α	.923	.772	

Table 42: Staff perceptions total variance explained

Component	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %	Rotation Sums of Squared Loadings Total	Rotation Sums of Squared Loadings % of Variance	Rotation Sums of Squared Loadings Cumulative %
1	6.749	51.913	51.913	6.749	51.913	51.913	4.999	38.457	38.457
2	1.265	9.731	61.644	1.265	9.731	61.644	3.014	23.187	61.644
3	.755	5.808	67.452						
4	.733	5.641	73.093						
5	.619	4.762	77.855						
6	.599	4.608	82.463						
7	.548	4.214	86.678						
8	.463	3.563	90.241						
9	.376	2.889	93.131						
10	.337	2.591	95.722						
11	.248	1.911	97.633						
12	.190	1.459	99.092						
13	.118	.908	100.000						

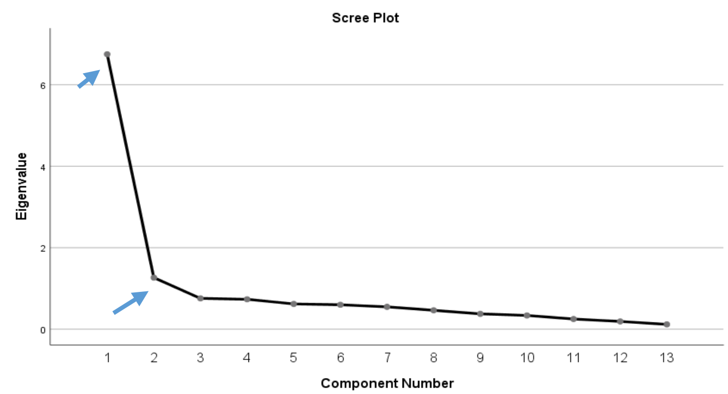


Figure 58. Staff perceptions scree plot test

4.7.2.5.2 Universities and Technology-Related Factors

Following appropriate factorability conditions (KMO: 0.877; $\chi^2 = 1797.824$ df = 66, p < .000) 12 observed variables under the AR integration strategies, EFA was subjected to technological infrastructure and usability through PCA and Varimax rotation (please see Table 44). The EFA identified two-factor solution accounting for the total variance (cumulative 65.7%). These factors were identified based on both Eigenvalues and the scree plot (please see Figure 59). Factors 1 and 2 contributed 48.7% and 17% to the total variance, respectively.

Items loaded onto factor 1 reflected ICT devices, universities' infrastructure, and the development and support that needs to be considered in terms of AR implementation in SA universities. This factor is called "**support and maintenance**".

Factor 2 consists of observed variables related to acceptability of use and ease of use. These items are reflected in the name of this factor, which was labelled "**design and usability**".

The minimum highest value was a .518 factor loading for both factors. Internal consistency for each of the measures was tested using Cronbach's alpha. The alphas were acceptable: .929 for factor 1 (8 items) and .759 for the second factor (four items). Thus, the scales were sufficiently reliable to measure academic and e-learning opinion towards the implementation of AR in SA universities.

In Table 43 to Table 45 below, the total variance explained factor loadings, communalities, and Cronbach's α are summarised.

UNIVERSITIES AND TECHNOLOGY-RELATED FACTORS

Table 43: Factor loading and Cronbach α results for universities and technology-related factors

Variables	Component 1	Component 2	Communalities
The university must have sufficient hardware	.885		.785
The university must have sufficient software	.869		.764
SAn Universities must provide technical support and maintenance to AR users	.864		.784
Testing AR systems is needed to assure that the system is easy for students and faculty members.	.861		.751
SAn Universities must have high-speed internet connectivity	.812		.660
SAn Universities should encourage appropriate assessment and evaluation of the impact of AR on teaching and learning.	.792		.685
AR training is needed to integrate it into my courses	.784		.636
Funding by the government and a sufficient budget are vital for AR integration	.581		.517
AR is easy to use		.787	.620
Faculty members and staff must have high user acceptance of AR technology		.778	.657
Students must have high user acceptance of AR technology		.746	.576
AR is easy to evaluate		.673	.456
Cronbach	**.929**	**.759**	

Table 44: KMO and B-Test universities and technology-related factors

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.877**
Bartlett's Test of Sphericity	Approx. Chi-Square	**1797.824**
	df	**66**
	Sig.	**.000**

Table 45: Total Variance Explained for universities and technology-related factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.849	48.738	48.738	5.849	48.738	48.738	5.339	44.491	44.491
2	2.044	17.031	65.769	2.044	17.031	65.769	2.553	21.278	65.769
3	.944	7.864	73.633						
4	.681	5.675	79.309						
5	.516	4.304	83.612						
6	.420	3.502	87.114						
7	.388	3.233	90.348						
8	.345	2.879	93.227						
9	.300	2.501	95.728						
10	.227	1.888	97.616						
11	.161	1.344	98.960						
12	.125	1.040	100.000						

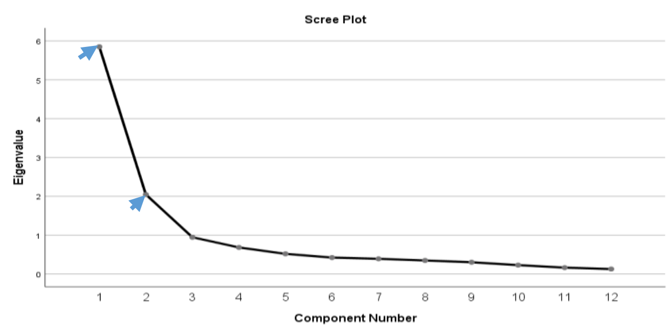


Figure 59. Scree plot for universities and technology-related factors section of staff survey

4.7.2.5.3 The Willingness of Integration and Contextual-Related Factors

Initially, factorability of the willingness of integration and sociocultural aspects had nine observed variables, and these were examined (KMO: .769; χ^2 = 870.984 df = 36, $p < .000$) (please see Table 46). Secondly, factor item correlations were mostly > 0.30. These indicators ensure that factor analysis was deemed to be suitable for this section. The scree plot (please see Figure 60) shows two factors contributing 40% and 22.6% of the total variance, respectively (cumulative 62.7%). All loadings less than 0.40 were omitted from the output. In this section, the Varimax rotation method was used to rotate the data.

Factor 1 included observed variables related to the readiness of e-learning and academic staff to use AR technology in universities. This factor was labelled "**AR readiness**". The second factor combined four observed variables reflecting the culture, beliefs, and religious issues that can influence integrating and effective use of AR as a learning method. It was named "**Sociocultural and norm factors**". The EFA indicated two factors with a minimum highest value of .684. Cronbach's alpha was used to examine the internal consistency for the retained factor items.

The alphas confirmed adequate internal consistency: .875 for AR readiness (five items) and .711 for sociocultural factors (four items). In Table 47 and Table 48 below, the explained total variance, factor loads, communalities and Cronbach α are summarised.

THE WILLINGNESS OF INTEGRATION AND CONTEXTUAL-RELATED FACTORS

Table 46: KMO and Bartlett's Test results for the willingness of integration

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.769**
Bartlett's Test of Sphericity	Approx. Chi-Square	**870.984**
	df	**36**
	Sig.	**.000**

Table 47: Factor loadings, Communalities, and Cronbach α for the willingness of integration and contextual related

Rotated Component Matrix[a]	Component 1	Component 2	Communalities
I am willing to use AR in my teaching and professional activities	.902		.814
AR should be introduced in my university	.829		.688
I am willing to use AR for activities concerning the teaching of course materials.	.810		.660
I am willing to learn more about AR technology	.789		.625
I will recommend using AR to my other colleagues	.721		.546
AR needs to be suited to the SAn religious environment		.770	.595
I want to do what my university head of department and dean in particular thinks I should do regarding using AR		.751	.637
AR can cause ethical concerns		.717	.579
I want to do what most lecturers and professors think I should do concerning using AR in teaching		.684	.502
Cronbach α	.875	.711	

Table 48: Total Variance Explained for the willingness of integration and contextual related factors

Component	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction % of Variance	Extraction Cumulative %	Rotation Sums of Squared Loadings Total	Rotation % of Variance	Rotation Cumulative %
1	3.607	40.083	40.083	3.607	40.083	40.083	3.474	38.595	38.595
2	2.039	22.652	62.735	2.039	22.652	62.735	2.173	24.140	62.735
3	.930	10.332	73.067						
4	.625	6.947	80.014						
5	.493	5.472	85.486						
6	.430	4.779	90.265						
7	.387	4.304	94.569						
8	.291	3.236	97.805						
9	.198	2.195	100.000						

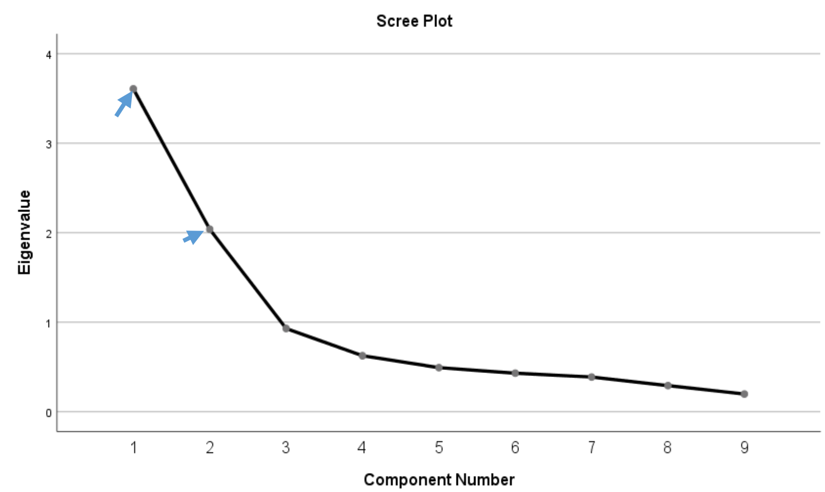


Figure 60: Scree plot for the willingness of integration and contextual-related factors

4.7.2.5.4 The Retained Factors (Staff Survey Section Analysis)

EFA was established for the staff survey by sections to ensure the validity by comparing it with the results of the analysis of the whole survey and then communicate both findings. Six factors were identified and labelled for the academic and staff survey sections analysis: (1) perceived AR pedagogical contributions; (2) perceived AR usefulness; (3) support and maintenance factors; (4) AR design and usability; (5) AR readiness; and (6) sociocultural and norm factors. Table 49 shows the Cronbach's alpha for the six improved factors in the academic and e-learning staff survey sections. Furthermore, the outcomes from sections analysis in the staff survey are demonstrated in Figure 63 as a concept map.

Table 49: The retained factors from sections analysis in the staff survey

Factor	*N* of items	Name (Label)	Cronbach's Alpha
1	8	Perceived pedagogical contributions	.923
2	5	Perceived usefulness	.772
3	8	Support and maintenance factors	.929
4	4	Design and usability	.759
5	5	AR readiness	.875
6	4	Sociocultural and norm factors	.711

4.7.2.6 Academic and E-Learning Staff Survey Results – Whole Survey EFA

EFA was conducted for the 34 structure items of Likert scale questionnaires under integrating AR factors in higher education in SA universities using the PCA and (orthogonal) Varimax rotational methods. Favourable subjects confirmed the factorability of structure items, the Kaiser-Meyer-Olkin measure of sampling adequacy had a KMO value of .901 (above the suggested value of .6), and Bartlett's Test of Sphericity was significant (χ^2 = 5185.087 df = 561, p < .000) (please see Table 50).

All loadings less than 0.40 were excluded from the output. Furthermore, the Scree test and Kaiser's criterion (the eigenvalue rule) were utilised to help identify a meaningful and accurate list of factors (please see Figure 61). Hence, the researcher, according to the earlier number of factors, determined the final number of factors.

The present findings of the factor analysis seem to be consistent with the previous analysis, which yielded a six-factor solution with a simple structure (factor loadings ≥.40). The eigenvalues demonstrated that the first factor explained 11.850%, the second factor 3.075%, the third factor 2.345%, the fourth factor 2.134%, the fifth factor 1.574%, and the sixth factor 1.368% of the total variance (cumulative 65.72%) (See Table 51).

In this survey study, the minimum highest value was .40-.45, as proposed by Hair et al. (2010). Interpreting the data in this survey analysis was also applied by selecting sorted by size and suppressing small coefficient options under the coefficient display format. The results of an orthogonal rotation of the solution, communalities, and Cronbach α are shown in Table 52 below. Loadings less than 0.40 were excluded.

The Total Variance Explained, Scree plot, factor loadings, communalities, and Cronbach's α are summarised below.

STAFF WHOLE SURVEY ANALYSIS SUMMARY

Table 50: KMO and Bartlett's Test for staff whole survey EFA

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.901**
Bartlett's Test of Sphericity	Approx. Chi-Square	**5185.087**
	df	**561**
	Sig.	**.000**

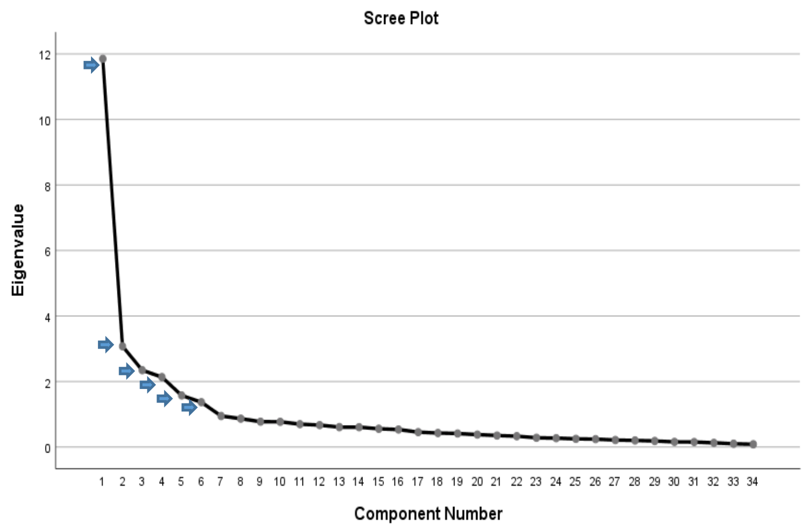


Figure 61. Scree Plot for staff whole-survey EFA

Table 51: Total Variance Explained and eigenvalue for staff whole survey

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.850	34.854	34.854	11.850	34.854	34.854	5.702	16.772	16.772
2	3.075	9.044	43.899	3.075	9.044	43.899	5.423	15.950	32.722
3	2.345	6.898	50.797	2.345	6.898	50.797	3.290	9.676	42.398
4	2.134	6.277	57.074	2.134	6.277	57.074	3.025	8.897	51.295
5	1.574	4.630	61.704	1.574	4.630	61.704	2.784	8.187	59.482
6	1.368	4.025	65.729	1.368	4.025	65.729	2.124	6.247	65.729
7	.947	2.786	68.515						
8	.866	2.547	71.063						
9	.775	2.278	73.341						
10	.771	2.267	75.608						
11	.697	2.050	77.657						
12	.670	1.969	79.627						
13	.608	1.789	81.415						
14	.605	1.779	83.195						
15	.557	1.639	84.834						
16	.535	1.573	86.407						
17	.454	1.334	87.742						
18	.428	1.258	89.000						
19	.412	1.212	90.212						
20	.378	1.113	91.325						
21	.351	1.034	92.359						
22	.331	.974	93.333						
23	.283	.832	94.165						
24	.270	.794	94.959						
25	.251	.737	95.696						
26	.241	.708	96.404						
27	.213	.628	97.032						
28	.201	.592	97.624						
29	.185	.544	98.168						
30	.158	.464	98.632						
31	.153	.450	99.082						
32	.128	.377	99.459						
33	.100	.295	99.754						
34	.084	.246	100.000						

Table 52: Factor loading, communalities, and Cronbach α for staff whole survey EFA

Rotated Component Matrix[a]									
Factor Label	Variable	Component							Communalities
		1	2	3	4	5	6		
Support and maintenance	The university must have sufficient hardware	.860							.799
	The university must have sufficient software	.844							.773
	SAn Universities must provide technical support and maintenance to AR users	.818							.790
	SAn Universities must have high-speed internet connectivity	.780							.659
	Testing AR systems is needed to assure that the system is easy for students and faculty members.	.778							.756
	AR training is needed to integrate it into my courses	.722							.634
	SAn Universities should encourage appropriate assessment and evaluation of the impact of AR for teaching and learning.	.720							.685
	Funding by the government and a sufficient budget are vital for AR integration	.602							.526
Perceived pedagogical contributions	AR is exciting		.884						.863
	AR is attractive		.826						.817
	AR is more interesting		.811						.756
	AR is enjoyable		.776						.726
	AR is a motivating learning method		.703						.691
	AR promotes self-learning		.617						.545
	AR will help to improve learning outcomes		.598						.595
	AR is a cooperative learning tool		.497						.461
AR readiness	I am willing to use AR in my teaching and professional activities			.783					.818
	AR should be introduced in my university			.728					.713
	I am willing to learn more about AR technology			.706					.645
	I will recommend using AR to my other colleagues			.692					.616
	I am willing to use AR for activities concerning the teaching of course materials.			.642					.693

Perceived usefulness	AR is suitable to apply in various subjects				.713			.598
	AR will allow me to do things that I cannot easily do now.				.641			.564
	AR is much better than traditional learning methods				.595			.524
	AR is saving time and effort for the teachers and students				.550			.561
	AR is expected to achieve the intended use				.500			.368
Acceptability and usability	Faculty members and staff must have high user acceptance of AR technology					.764		.677
	Students must have high user acceptance of AR technology					.753		.637
	Easy to use					.725		.636
	Easy to evaluate					.614		.576
Sociocultural and norm factors	AR needs to be suited to the SAn religious environment						.818	.736
	AR can cause ethical concerns						.761	.638
	I want to do what my university head of department and dean in particular thinks I should do regarding using AR						.678	.621
	I want to do what most of lecturers and professors think I should do concerning using AR in teaching						.571	.651
Number of test measures		**8**	**8**	**5**	**5**	**4**	**4**	
Alpha Reliability		**.929**	**.923**	**.875**	**.772**	**.759**	**.711**	

Overall, EFA illustrated that six distinct components were underlying academic and e-learning staff responses to AR perception and integration and that these factors were moderately internally consistent. It can be seen from the data in Table 52 above, that those variables with a higher loading on each factor will influence the naming of that factor. Each variable was carefully examined to determine an appropriate name for that factor. In the following section, improved extracted factors are discussed in detail, including each factor name and variables.

4.7.2.6.1 Academic and E-Learning Staff, Six Topic Factors and Reliability (Whole Survey)

The researcher decided to name the factors based on the higher one or two loading items for each factor as well as using previously selected factor names. The Alphas found indicated strong internal consistency (α = .929; .923; .875; .772; .759; .711 for factor 1, factor 2, factor 3, factor 4, factor 5, and factor 6 respectively).

Eight items loaded onto Factor 1. As can be seen from Table 52 above, these eight items all related to AR technology requirements from ICT devices, infrastructure, and the support from the universities. The first variable focused on the importance of the availability of technology hardware. Likewise, the second variable also concentrated on providing technology software to build and utilise this technology. The third variable is related to technical support and maintenance, which is vital to ensure the successful post-implementation use of AR technology. Variable four focused mainly on internet connectivity and accessibility that must be provided to improve the efficient use of AR in the education sector. The fifth variable reflected the system testing stage to ensure that the AR system is easy for students and faculty members to use. Item six related to training academic members and lecturers in the use and design of AR technologies in teaching. The seventh variable reflected the importance of regular evaluation and assessment to identify the effects of using AR in education and improving its efficiency. The final item in Factor 1 was related to a sufficient budget and funding for AR integration. This factor was labelled **“Support and maintenance”.**

The eight items that highly loaded onto Factor 2 related to the AR capabilities and potential pedagogical contributions to make teaching and learning in the higher education exciting, attractive, more interesting, enjoyable and motivating. The last items in Factor 2 focused on the pedagogical assistances of AR to promote self-learning, improve learning outcomes, and make learning more cooperative. Therefore, this factor was named "**perceived pedagogical contributions".**

Factor 3 consisted of five variables. The five variables constituted the willingness factor. This is because the first, third and fifth variables focused on academic and e-learning staff's willingness to learn about AR and use it in their teaching and professional activities. Accordingly, this factor was named **"AR readiness"**.

Items for Factor 4 represented the usefulness of using AR as an instructional tool. The first highest loading variable reflected the usefulness of AR to be applied in various subjects. The second highest variable focused on the usefulness of AR in facilitating lecturers' teaching practice. The third variable related to lecturers' preferred teaching method. The fourth variable reflected the usefulness of AR technology in saving time and effort for the teachers and students. The last item is related to e-learning and academic staff expectations of the usefulness of AR in SA universities. Thus, this factor was labelled **"perceived usefulness".**

Factor 5 included four variables. The first and second high loaded variables focused mainly on the acceptability of using AR in an educational context. The third and fourth items related to the ease of use. All these items related to usability. Therefore, this factor was named **"acceptability and usability".**

Factor 6 consisted of four items. The first item addressed the religious issue that might influence the use of AR in SA. The second items related to the suitability of AR to the ethical standards of the SA cultural environment. The remaining items focused on normative beliefs towards using AR in teaching. This factor was named **"sociocultural and norm factors."**

The factor labels and results of the reliability test are presented in Table 53 below. Moreover, the outcomes of the whole staff survey analysis are presented in Figure 64 as a concept map.

Cronbach's Alpha for all 34 items	N of Items
.923	34

Table 53: AR factors and reliability from the whole staff survey

Factor	*N* of items	Name (Label)	Cronbach's Alpha
1	8	Support and maintenance factors	**.929**
2	8	Perceived pedagogical contributions	**.923**
3	5	AR readiness	**.875**
4	5	Perceived usefulness	**.772**
5	4	Acceptability and Usability	**.759**
6	4	Sociocultural and norm factors	**.711**

4.7.2.7 E-Learning and Academic Staff Comments' Analysis

The academic and e-learning staff were encouraged to make additional comments regarding AR use in the SAn higher education sector. It was found that some lecturers and e-learning staff feel that universities would benefit from outsourcing to co-adopt this technology. Some lecturers feel developing classrooms by providing special laptops equipped with AR software and hardware and preparing students and faculty members through workshops, will guide the successful implementation of AR technology in education.

Also, they were encouraged to make additional comments on other factors that might facilitate or influence the integration of AR in universities. Figure 62 presents the most frequently occurring words that enabled the researcher to discover more factors from the participants' comments. As shown in Figure 62, some participants expressed the belief that workshops, training and support to develop AR design skills are essential. Besides, some believed that although SA universities can provide all the technical requirements, AR needs to be accepted by lecturers and teachers. Another commented that the cost of adopting AR in terms of material, human, effort, and time should be taken into consideration.

Figure 62: staff world clouds analysis

4.7.2.8 Academic and E-Learning Findings Concept Maps

The results of the EFA using both techniques are summarised in Figure 63 and Figure 64 below. The factor loading is presented in different colours.

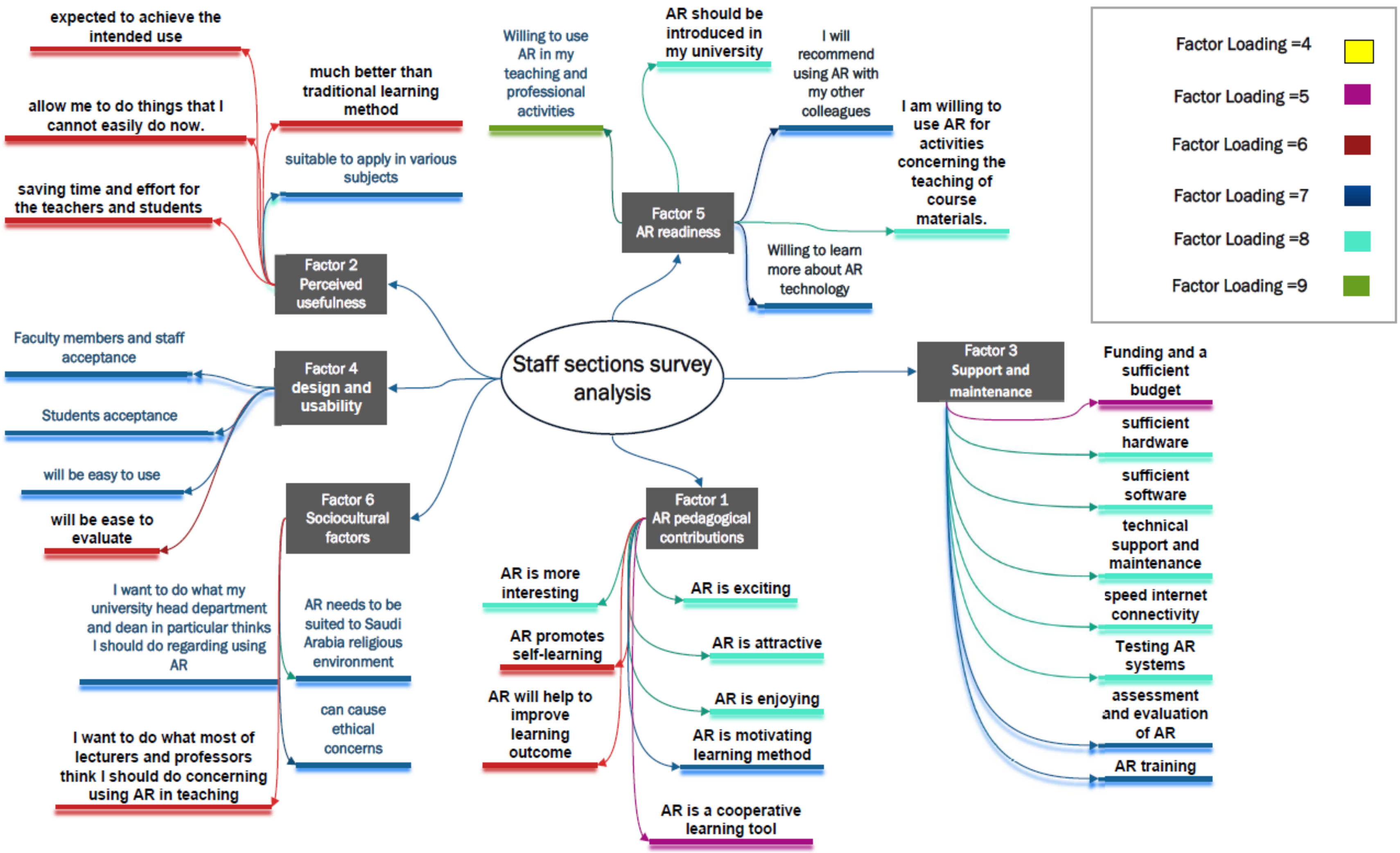


Figure 63: Concept maps illustrating staff survey results (sections analysis)

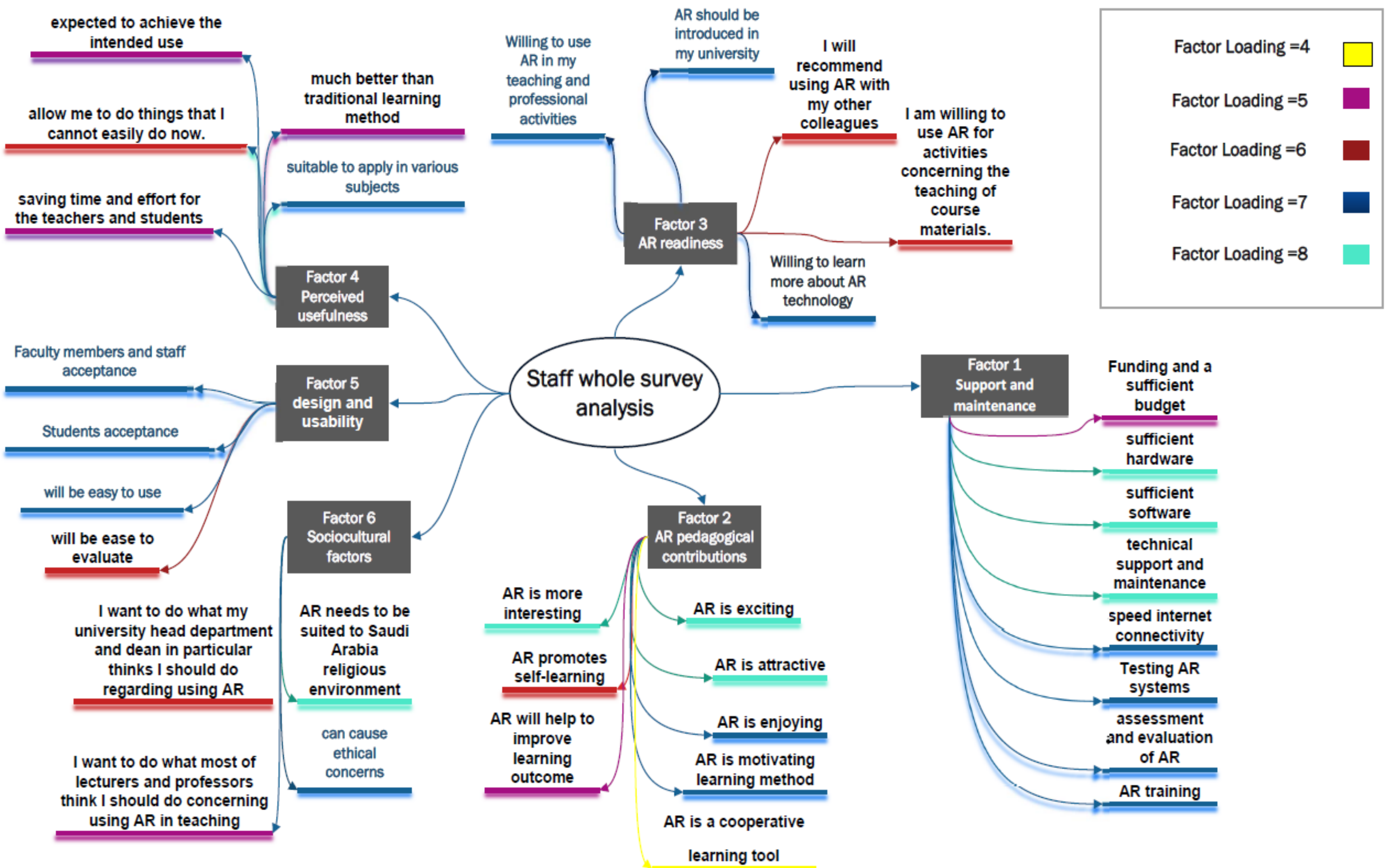


Figure 64: Concept maps illustrating staff survey results (whole-survey analysis)

4.7.2.9 Summary of E-Learning and Academic Staff Online Survey Outcomes

In the previous sections, the survey focused on the perceptions of e-learning and academic staff in SA universities. Data were analysed and explored to find the factors that needed be added when developing an AR framework for higher education in SA. Using a hyperlink via Qualtrics survey software, 228 subjects were recruited from e-learning and academic staff in SA universities to participate in an AR survey. The demographic profiles of academic staff were elicited. Academic and e-learning staff are highly qualified with at least a master and diploma's degree. Also, most of them indicated a high level of using technology in their current professional activities. Further analysis showed that a high percentage (81%) of academic and e-learning staff are well experienced in using the computer. Furthermore, staff reported a high level of interest in technology, and most of the staff participants (78%) are knowledgeable about AR technology.

EFA was performed for producing a new array of stable factors from both academic members and e-learning department staff. Also, two techniques were applied to form the reliability and validity of the survey data: analysing the academic and e-learning survey sections and then analysing the whole survey.

The results obtained from both techniques were similar in terms of factors and items (please see Figure 63 and Figure 64). Therefore, factors were well measured by their indicators and all included in the revised framework. Six factors were obtained from the e-learning and academic staff survey in both analyses (please see Table 49 and Table 53). Eigenvalue and scree plot results supported these factor solutions. These findings from the academic and e-learning staff surveys were then discussed. Cronbach's alpha determined the internal consistency of each variable. Cronbach's α generated internal consistency with values exceeding the recommended 0.7.

Based on the online survey outcomes from students, academic staff, and e-learning staff, an AR framework for SA universities was established. The factors suggest that adopting AR technology in SA higher education is not only a technical issue but a rather complicated issue comprising various aspects such as social settings and individual characteristics. The final factors are discussed in detail in the next chapter.

4.8 AR Framework for SA Universities and the Improved Factors

The initial objectives of the study were to identify and classify the factors that must be included when developing an AR framework for universities in SA and identify students', faculty members', and e-learning staff's perceptions towards the AR method of teaching compared with the traditional method. The factors are intended to offer a useful point of reference for decision-makers to integrate AR technology as it is planned, designed, developed, and used in SA universities.

The questionnaire questions slightly differed in students and staff surveys to obtain reliable results. Factor analysis was conducted to help the researcher to arrange the variables to obtain an enhanced set of factors that will contribute to an AR framework for SA universities as well as ensure an accurate representation of educational AR factors from students', lecturers' and e-learning staff's perspectives. The results yielded factors that were almost the same except for two different factors in both results. The differences are related to technological infrastructure and implementation support questions that were directed to academic and e-learning staff but did not require responses from students. Additionally, emotional and cognitive questions were directed to students but not to academic and e-learning staff. Therefore, the findings from both students and academic staff were combined to develop a new set of robust factors. The result of the factor analysis for both surveys yielded factors that shaped the second draft of the AR framework for SA universities as demonstrated in Figure 65 below, which summarises the main factors derived from both analysis techniques, (please see Figure 53, Figure 54, Figure 63, and Figure 64), of all surveys. Table 54 below includes the name, description and variables for each factor.

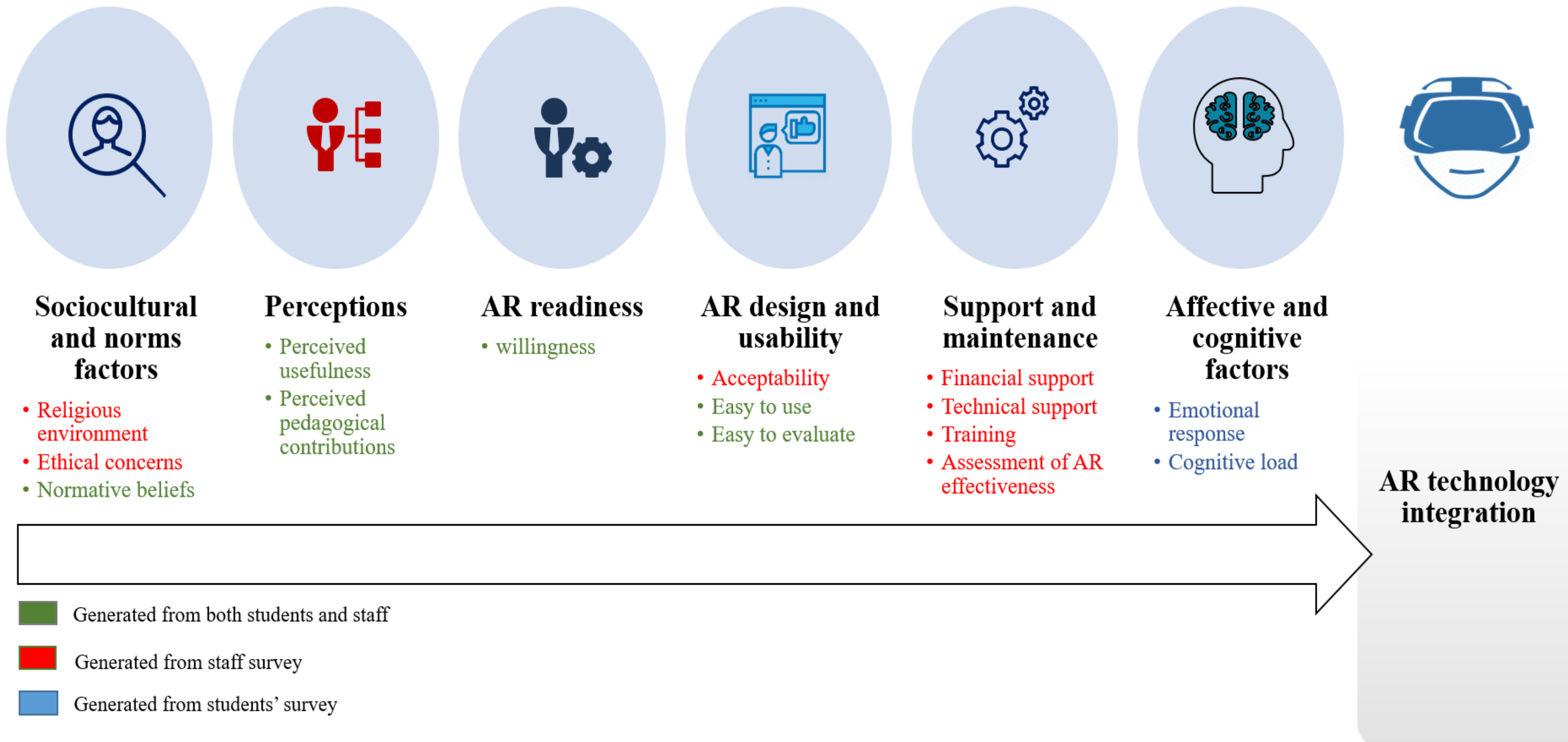


Figure 65: A highlight of the surveys' findings for staff and students

Table 54: Interpretation of factors contributing to the AR framework

Factor Name	Description	Variables	Original factors from AR Framework
Sociocultural and norms factors	This factor combines variables reflecting social, cultural and religious issues that can influence the integration and effective use of AR as a learning method. The other variables reflected normative beliefs concerning using AR in learning. These variables focused on the influence of peers, teachers, deans, and heads of the department towards AR technology in university learning.	AR needs to be suited to the SAn religious environment	Social factors (Culture)
		AR can cause ethical concerns	Social factors (Culture)
		I want to do what my university head of department and dean, in particular, thinks I should do regarding using AR	Social factors (beliefs)
		I want to do what most lecturers and professors think I should do concerning using AR in teaching information.	Social factors (beliefs)
		I want to do what most of the students think I should do concerning using AR in my learning	Social factors (beliefs)
		I want to do what my teachers, in particular, think I should do regarding using AR	Social factors (beliefs)
		People, who are important to me, would approve my using AR in my learning.	Social factors (beliefs)

Factor Name	Description	Variables	Original factors from AR Framework
Perceptions (Perceived usefulness)	This factor reflects a participant's perception that using AR as an educational tool would be an advantage to the teaching and learning process and suitable for different subjects, ages and genders.	AR will assist in learning and teaching	Personal factor (perceptions)
		AR will allow me to do things that I cannot easily do now.	Personal factor (perceptions)
		AR saves time and effort for the teachers and students	Personal factor (perceptions)
		AR is much better than the traditional learning methods	Personal factor (perceptions)
		AR is expected to achieve the intended use	Personal factor (perceptions)
		AR is suitable for different genders	Personal factor (Gender)
		AR is suitable for different ages	Personal factor (Ages)
		AR is suitable to apply in various subjects	Personal factor (perceptions)

Factor Name	Description	Variables	Original factors from AR Framework
Perceived pedagogical contributions	This factor reflects a participant's perception that using AR as an educational tool would contribute to pedagogy to make effective use of technology.	AR is exciting	Personal factor (perceptions)
		AR is attractive	Emotional factor
		AR is more interesting	Personal factor (perceptions)
		AR is enjoyable	Personal factor (perceptions)
		AR is a motivating learning method	Emotional factor
		AR promotes self-learning	Personal factor (perceptions)
		AR will help to improve learning outcomes	Personal factor (perceptions)
		AR is a cooperative learning tool	Personal factor (perceptions)
		AR takes less time to deliver the information	Personal factor (perceptions)
		AR as a learning tool is engaging	Personal factor (perceptions)
		AR will assist my learning efficiency	Personal factor (perceptions)

Factor Name	Description	Variables	Original factors from AR Framework
AR readiness and willingness	This factor represents a participant's willingness to accept and use AR technologies in teaching and learning in SA universities.	I am willing to use AR in my teaching and professional activities	Personal Factor
		AR should be introduced in my university	Personal Factor
		I am willing to learn more about AR technology	Personal Factor
		I will recommend using AR to my other colleagues	Personal Factor
		I am willing to use AR for activities concerning the teaching of course materials.	Personal Factor
		Willing to use AR in my learning	Personal Factor
		I like to use AR in my learning at the university	Personal Factor
		I will use AR for learning activities	Personal Factor

Factor Name	Description	Variables	Original factors from AR Framework
AR design and usability	This factor represents a participant's perception of AR acceptability and usability, which focuses mainly on easiness to use in teaching and learning.	Faculty members and staff must have high user acceptance of AR technology	usability
		Students must have high user acceptance of AR technology	usability
		Easy to use	usability
		Easy to evaluate	usability

Factor Name	Description	Variables	Original factors from AR Framework
Support and maintenance	This factor reflects a participant's perception of the availability and quality of development and supports during use to provide greater integration of AR technology.	The university must have sufficient hardware	Infrastructure
		The university must have sufficient software	Infrastructure
		SAn universities must provide technical support and maintenance to AR users	Support and maintenance
		SAn universities must have high-speed internet connectivity	Infrastructure
		Testing AR systems is needed to ensure that the system is easy for students and faculty members.	Evaluation
		AR training is needed to integrate it into courses	Training
		SAn universities should encourage appropriate assessment and evaluation of the impact of AR on teaching and learning	Evaluation
		Funding by the government and a sufficient budget are vital for AR integration	Economic

Factor Name	Description	Variables	Original factors from AR Framework
Affective and cognitive factors	This factor represents a participant's perception of AR effectiveness in learning, which, might hinder or encourage the integration of AR technology in the education sector.	AR as a learning tool is frustrating	Emotional factor
		AR as a learning tool is confusing	Emotional factor
		AR will help me to improve my spatial skills	Cognitive factor
		AR will help me to remember the learning material easily	Cognitive factor
		AR will help me to keep my attention on the learning task	Cognitive factor
		AR as a learning tool is attractive	Emotional factor

As a result of this phase of the research, several changes were made to the framework. These changes involved combining factors and renaming some factors based on EFA results and the outcomes of this phase. For example, the name “Social factors” was changed to “Sociocultural and norms factors” because, based on analysis of the results, the researcher thought that this name was a more appropriate description of the sub-factors under this title after analysis.

The initial framework contained factors called “Economy”, “Infrastructure”, “Evaluation”, and “Training” which were grouped under “Support and Maintenance” for specific reasons. The dimensions of these factors were included under one factor based on analysis of the results. Support and maintenance include not only IT support but also budget, training and assessment. The researcher believed that these also relate to “Support and Maintenance”; therefore, it is an appropriate title for this group. Similarly, the factors named “Emotional factor”, and “Cognitive factor” in the initial AR framework (Figure 28); were merged into one factor called “Affective and cognitive factors” as a result of EFA analysis and outcomes.

Another essential adjustment was adding essential factors to the initial framework based on the outcomes of this phase. Initially, the framework contained a factor called “Personal factors” which was separated based on analysis of the results into three factors namely “Perceived usefulness” and “Perceived pedagogical contributions” and “AR readiness”. Table 55 below shows the changes that were made to the revised framework.

The enhanced AR framework is illustrated in Figure 66 below. It will be used to formulate the SS interview method described in the next chapter. The qualitative stage of the study will be conducted to validate the identified factors in the improved AR framework. The AR framework resulting from the interviews is the final version, including the factors that influence the integration of AR technology in SA. Therefore, an enhanced AR framework is the basis for the qualitative stage of this research.

Table 55: Changes (in red) that were made to the revised framework

Initial AR Framework factors	Finding Post Surveys
Sociocultural factors	**Sociocultural factors and norms**
• Religion • Ethics and privacy • Culture • Normative beliefs	• Religious environment • Ethical concerns • Normative beliefs
Personal factors	
• Age • Gender • Perception of technology • Attitude • Willingness or readiness	• Age • Gender • Perceived usefulness • Perceived pedagogical contributions • Willingness or readiness
"Emotional factor", and "Cognitive factor."	**Affective and cognitive factors**
• Pleasing • Engaging • Attractive • Motivating • Fun • Cognitive load • Prior knowledge • Spatial Ability	• Cognitive load • Attention • Remembrance
University-related factors	**Support and maintenance**
• Budget • Financial support • Hardware • Software • Internet connectivity • Technical support • Institutional support • Professional training and development • System efficiency improvement • Assessment technology effectiveness	• Financial support • Technical support • Training • Assessment of AR effectiveness
Design and Usability	
• Easy to use • Easy to evaluate • Safe to use • Enjoyable • Satisfying	• Acceptability • Easy to use • Easy to evaluate

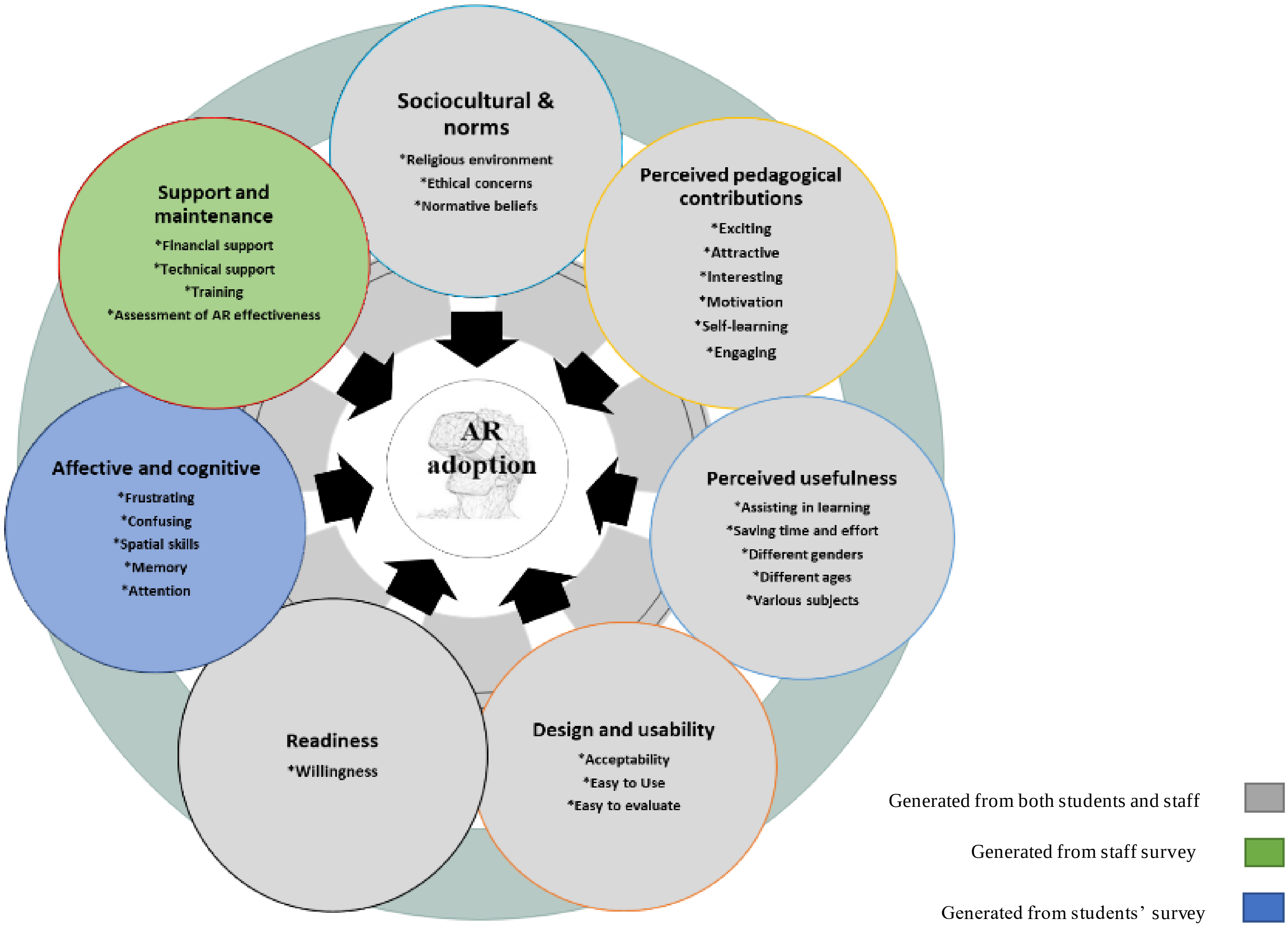


Figure 66. Refined AR framework for SA universities

4.9 Conclusion

This chapter presented an overview of the first evaluation phase of the AR framework for Saudi universities. The main objective of the quantitative stage was to validate the factors that were identified from academic sources and the literature review. The quantitative process also explored an enhanced set of factors that could further improve the AR framework. In this chapter, the survey design was discussed, and the survey population and the data analysis were presented. The researcher surveyed a sample of 729 cases (501 students, 228 academic and e-learning staff). A web-based survey was utilised to collect the data that was then analysed using the SPSS program.

The preliminary analysis produced a list of factors contributing to the adoption of AR in the Saudi higher education sector. The factor analysis technique was applied to identify sets of correlated factors and generate a new set of robust factors. Participants' perceptions were revealed. Technology usefulness and technology pedagogical contributions were found to be essential perceptions that encouraged students and faculty members to adopt AR in the higher education system. Based on the online survey findings and the literature, university support, AR design and usability, readiness, sociocultural and norms, and affective and cognitive factors were found to drive the incorporation of AR technology in universities in SA. Hence, for this study, this phase was used to explore the answer for the first and second research questions. Finally, the changes that were made to the AR framework are covered in this chapter by presenting the survey outcomes that resulted in an improved AR framework for SA universities. Most of the factors were strongly supported. A revised version of the framework in Figure 66 shows several changes compared to the previous version in Figure 28. These changes included removing some survey items from the subsequent factor analysis because they were not loaded cleanly on a single factor and some factors were merged into one factor; for instance, emotional factors and cognitive factors become the affective and cognitive factor.

The next chapter analyses and discusses the SSI phase. The findings from the analysis are used to refine the AR framework further.

Chapter 5. Qualitative phase

5.1 Introduction

Chapter Four focuses on providing a general description of the quantitative approach implemented in the responses of the survey. It also addresses the analysis of data resulting from surveys applying analytical software, such as SPSS and NVivo. It demonstrated the developments made to the proposed AR framework, and how the findings of the survey enhanced the list of factors. The enhanced AR framework was introduced at the end of chapter 4, and it provides the basis for this stage of the research.

This chapter outlines the qualitative method, as well as a description of the evaluation of the enhanced AR framework. As discussed in section 3.3.5, the data in this study were collected sequentially in different stages. From the outcomes of the literature review, the quantitative method was conducted which offered a broad view of the research issue; then the qualitative stage followed to attain a more in-depth perception of AR in SA higher education from the experts, the lecturers, professors and e-learning staff, who may use these technologies in the teaching and learning context, to better understand the key factors that contribute to the adoption of AR technology.

Interviews were carried out to support the quantitative findings and to assess, refine and enhance the result to reach the final form of the AR framework. There are two rationales for performing interviews in the second phase in the study. The first is to confirm the first research question answers from the experts' visions in order to gain a better understanding and to explore the reason why and how these factors are important to be considered in AR adoption framework. The second is to investigate the experts' perspective towards AR adoption factors by answering the third question of the study and evaluate the AR framework resulting from the survey stage. Interview data will be analysed, and the description of the interviews will be illustrated to provide critical concepts covering feedback on the improved AR framework for SA universities. At the end of this chapter, the final AR framework is presented.

5.2 Design and Rationale of the Interview

This section presents the design and the rationale for selecting online semi-structured interview over other interview approaches. Then, the analysis and coding will be discussed, and the number of interviewees and their work titles and experiences.

Words are used in the qualitative method to provide clarification of a phenomenon which has occurred naturally (Krathwohl, 1998, 2004). There are several qualitative data collection techniques that have been established by the researchers. The interview is among the most common and crucial qualitative data collection methods (Qu & Dumay, 2011; Yin, 2011). In line with the qualitative procedure, this research aims to explore various perspectives and experiences on the integration of AR in higher education as well as to explain the results derived from quantitative data and analysis and to unearth additional factors and assess the framework. The online semi-structured interview was applied in this research, and the reasons for selecting the semi-structured interview were discussed in section 3.3.5.6.

It was difficult for the researcher to conduct face-to-face interviews with females or on the phone in Saudi society due to cultural reasons that were discussed in section 1.8.1. The SSI with the interviewees was collected via the Qualtrics platform, which enabled them to convey their thoughts about the ideal set of factors encompassing the framework. Therefore, the same technique (online interview) of data collection was conducted by both males and females to prevent bias and differences in the results. The interview method was designed in three parts.

The first section included general questions. These questions are intended to investigate other or more detailed factors and items that encourage universities to integrate AR as students and faculty members' surveys showed agreements with identified factors.

Therefore, these questions were posed to extract more information about the essential integration factors.

The second section sought the interviewees' opinions and evaluation regarding the contributing factors for incorporating AR into SAn universities to determine whether these factors are critical for the adoption of AR and further seeks to provide more information on these factors.

The third section of the interviews was for the interviewees' comments and evaluation of the whole set of factors and the developed AR framework. The interviews' design and the steps that were taken to conduct this phase are summarised in Table 56 below.

Table 56: The design of the interview

Process	**Action that was taken prior, during and after the interview phase of the research**
Interview objectives	The purposes of the interviews are: • To answer the third question of the study by examining the experts' perceptions. • To confirm and assess the new findings from the quantitative phase. • To obtain additional factors and recommendations which could help to incorporate AR technology in SA universities.
Interview question development	Online SSI questions were developed based on the results of the quantitative phase of data collection. The questions were open-ended and developed and edited by supervisors.
Interviewee Identification	Purposive sampling was used in this phase to obtain specialists who have AR experience in the higher education field.
Conducting the Interviews	There were five rounds of data collection: eight interviews were conducted in the first round, three in the second round, four interviews were conducted in the third round; two interviews were conducted in the fourth round, and two interviews conducted in the last round. All interviewees completed the interviews offline via Weblink sent to them through their email.

Coding	• The NVivo program was utilised to do thematic analysis with the coding. • The interviews were revisited, and paper coding through mapping techniques was done. • Then, a holistic approach coding was done in NVivo program again.

5.3 Reaching out to the Interviewees

As discussed in section 3.3.5.7, the sample was intentionally selected according to the study purpose. Since AR technology will be introduced in a university environment, members of e-learning deanship, ICT heads of department, educational technology designers, and faculty members were targeted for the interviews. To start communicating with the selected interviewees, an invitation letter was prepared to contain the following:

- Introduction with general information about the study.
- The aims of the interviews.
- The research outcomes and benefits
- A declaration indicating the willingness of the researcher to present the results at the end of the study.
- Statement of maintaining confidentiality and privacy in the research.

The invitation letter was distributed in August 2018 through two methods. As mentioned in section 3.3.5.6, the first method was through visiting each university's website to search for possible interviewees and obtain their contact details. After identifying the interviewees, the researcher sent them the invitation letter through their emails.

In the second method, the researcher used LinkedIn, which is a business and employment-focused service that works via mobile apps and websites, to send the invitation letter to interviewees who have experience in AR technology in the education field. LinkedIn has advanced search functionalities that allowed the researcher to find the target sample based on particular criteria such as job title, experiences, and education background (Bradbury, 2011). At least a week later, a reminder letter was prepared by the researcher and sent to encourage the non-responding individuals to take part in this study. The interview rounds are illustrated in Table 57. It can be seen that the number of interviewees who expressed interest in the study was much more than completed interviews received.

Table 57: The stages of the interviews

Round	Interviewees number	Email Invitation	Reminder email	No. of interviewees interested in the study	No. of completed interviews
1	22	20/08/2018	05/09/2018	14	8
2	15	10/09/2018	20/09/2018	5	3
3	18	5/10/2018	25/10/2018	7	4
4	4	10/11/2018	23/11/2018	2	2
5	6	3/12/2018	18/12/2018	3	2

In the interview phase, 19 interviewees completed the interview questions, while 31 interviewees agreed to take part in the interview. However, the researcher decided not to conduct more interviews after the fifth round as theoretical saturation had been achieved and the new data was redundant as more than one participant mentioned and confirmed most of the themes and criteria already collected in this study. According to Saunders et al. (2018, p. 1897), saturation is achieved when "new data repeat what was expressed in previous data". Some individuals did not continue the interview because they were busy.

Most of the interviewees preferred having the interview questions sent in a web link to their emails or LinkedIn profile pages to complete it in their spare time. The distribution methods of the interview invitation letter for each participant is illustrated in Table 58.

Table 58: Distribution methods

Round	No. of interviewees	Interviewee name	Distribution method
One	**8**	**P1** **P2** **P3** **P4** **P5** **P6** **P7** **P8**	**Email** **Email** **Twitter** **Email** **Email** **Email** **LinkedIn** **Email**
Two	**3**	**P9** **P10** **P11**	**LinkedIn** **Email** **LinkedIn**
Three	**4**	**P12** **P13** **P14** **P15**	**LinkedIn** **LinkedIn** **LinkedIn** **LinkedIn**
Four	**2**	**P16** **P17**	**Email** **LinkedIn**
Five	**2**	**P18** **P19**	**LinkedIn** **Email**

5.4 Data Analysis

Several forms can be used to analyse the qualitative data "reflecting the particular kind of data being used and the particular purposes for which they are being studied. There is, therefore, no single approach to the analysis of qualitative data that covers all situations" (Denscombe, 2010, p. 272). In this phase, the thematic analysis technique was selected to analyse the data from the interviews. Thematic analysis, as defined in section 3.3.5.9, is considered a qualitative descriptive method that provides researchers with assessment skills to perform many qualitative analysis forms (Nowell et al., 2017). The main goal of using this method is to provide an understanding and description of answers. The thematic analysis provides a rich and detailed account of the data as a useful and flexible research technique (Braun & Clarke, 2006). It was applied for exploration, investigation, and identification of essential patterns, subjects and relations in a data set. The advantages of using thematic analysis are that researchers can summarise critical features of an extensive data set by providing structure for handling the data and therefore facilitating an organised and transparent final report (King, 2004). According to Braun and Clarke (2006) and King (2004), thematic analysis is a beneficial method for exploring the participants' perspectives for different research, providing unanticipated insights, and highlighting similarities and differences. Qualitative thematic and content analysis "involves a process designed to condense raw data into categories or themes based on valid inference and interpretation" (Zhang & Wildemuth 2009, p. 2). The objective in the qualitative thematic analysis is to systematically convert a large amount of text into a highly structured summary of the core results.

The qualitative thematic analysis includes two main procedures, deductive and inductive. In the deductive thematic analysis, a predetermined framework or structure is applied to analyse data (Nowell et al., 2017). The data will be analysed based on identifiable themes or theories. This approach is mainly useful when the themes or categories have already been identified and used to cluster the data, and then the researcher looks for similarities and differences. Whereas, the inductive procedure mainly depends on the data to generate the themes and categories and the researcher codes the data without attempting to place it in an existing coding frame or analytical preconceptions of the researcher (Braun & Clarke, 2006). Coding is an analytical process that includes repeat steps between working and re-working with data until it is in a standardised form that tells a story (Richards & Morse, 2007). The coding is defined as "the process by which raw data are gradually converted into usable data through the identification of themes, concepts, or ideas that have some connection with each other" (Austin & Sutton, 2014, p. 439). According to Stemler (2001), there are two approaches to code the data: a priori coding where codes are generated beforehand and applied to the text, and developing coding where codes are derived from the text.

In this study, both inductive and deductive thematic analysis with a priori coding were applied to analyse the interview data with the coding prepared via NVivo (12). The deductive thematic analysis and prior coding were chosen in this study because coding and themes were directed by existing factors and themes that were already identified from the quantitative phase, and thus, it facilitated the interpretation of identifiable themes. The inductive thematic analysis was also applied for the new emerging themes. NVivo was used to import the transcripts and undergo thematic coding and analysis. The data from the transcripts were organised in NVivo via a categorising mechanism which enables the data to be labelled in themes called nodes which are encoded in the software. As mentioned in section 3.3.5.9, the process of thematic analysis in this research was guided by Braun and Clarke's (2006) six phases.

Firstly, the data were organised and prepared. Two hundred and nine transcribed pages were generated from the 19 interview transcripts. The researcher started analysing the interview data by reading the transcripts many times to become thoroughly familiar with the data.

Secondly, interesting data features were coded across the entire data set, and relevant data were gathered in each code. After reading through all the interview data, individual themes were used by the researcher as the coding unit. As Zhang and Wildemuth (2009, p. 3) point out: "when using the theme as the coding unit, you are primarily looking for the expressions of an idea. Thus, you might assign a code to a text chunk of any size, as long as that chunk represents a single theme or issue of relevance to your research question."

Thirdly, as mention previously, in this phase of the study, the inductive and deductive content analysis was used to analyse the interview data. Hence, the list of themes was generated based on the quantitative phase's (survey) pre-defined topics (factors) and some of the themes were renamed based on the interview data analysis. Similar codes were gathered together into each theme. This process is supported by Miles and Huberman (1994) who argue that when conducting a deductive thematic analysis, primary topics or themes created from previous search stages, theory, or modelling can be used as the basis for the research themes. An initial category list can be produced from a previous research model, and the model may be modified if any new categories emerge from the analysis.

In the fourth stage, the 19 transcripts were carefully re-read. Then, the pre-defined themes were checked, highlighted and matched with the relevant data. The researcher identified the emerging themes and reviewed the themes again to remove any overlap if more than one theme contained the same segment of the text and generate a thematic map of the analysis (Creswell, 2008).

In phase five, to generate clear names and definitions for each theme, the data and developed themes were reviewed and refined to identify any new themes and in order to generate clear names for each theme. The researcher rechecked the interview transcripts many times for validation and compared the outcomes with the matching factors that resulted from the quantitative stage.

Finally, after all the themes were identified at this stage, they were compared with the previous stage and organised into factors to create a comprehensive approach to the key results. The new findings were also checked to find whether the outcomes correspond to the literature (Burnard, 1991; Morse & Richards, 2002). Eight key factors resulted from the analysis and common themes that form the final research framework of the study. Compelling and vivid examples related to these factors, research questions and literature were added to support the result and validate it. Table 59 shows the six phases of thematic analysis.

Table 59: Thematic analysis, adopted from Braun and Clarke (2006).

Phase	Process description
1. Familiarising yourself with your data:	Transcripts were read many times to fully understand the data.
2. Generating initial codes:	Codes were defined across the entire data, and data relevant to each code was collated.
3. Searching for themes:	A theme list was produced based on predetermined topics (factors) from the quantitative phase (surveys) and all data relating to each potential topic were merged.
4. Reviewing themes:	The themes were matched with the extracted codes. Similarities and differences between the combined themes were examined. Similar themes were combined under the same category.
5. Defining and naming themes:	The specific characteristics of each theme were reviewed and refined. These were compared with the corresponding factors derived from the survey to validate them and to generate clear names and definitions for each theme.
6. Producing the report:	Eight key factors resulted from the analysis with examples that relate to the themes that form the final research framework of the study.

Seven categories and 15 main themes of the framework were created in this study, with 18 questions that were answered by interviewees. A confirmatory thematic approach was utilised to code the data, and themes were coded deductively according to pre-defined topics (factors) derived from literature as well as from the findings of the quantitative phase (surveys). Figure 67 displays an example of the data collected from a faculty members' interview that was coded for analysis purposes. Themes were examined and refined to combine similar themes under the same category and arrange them within the framework. Figure 68 illustrates the interview coding tree.

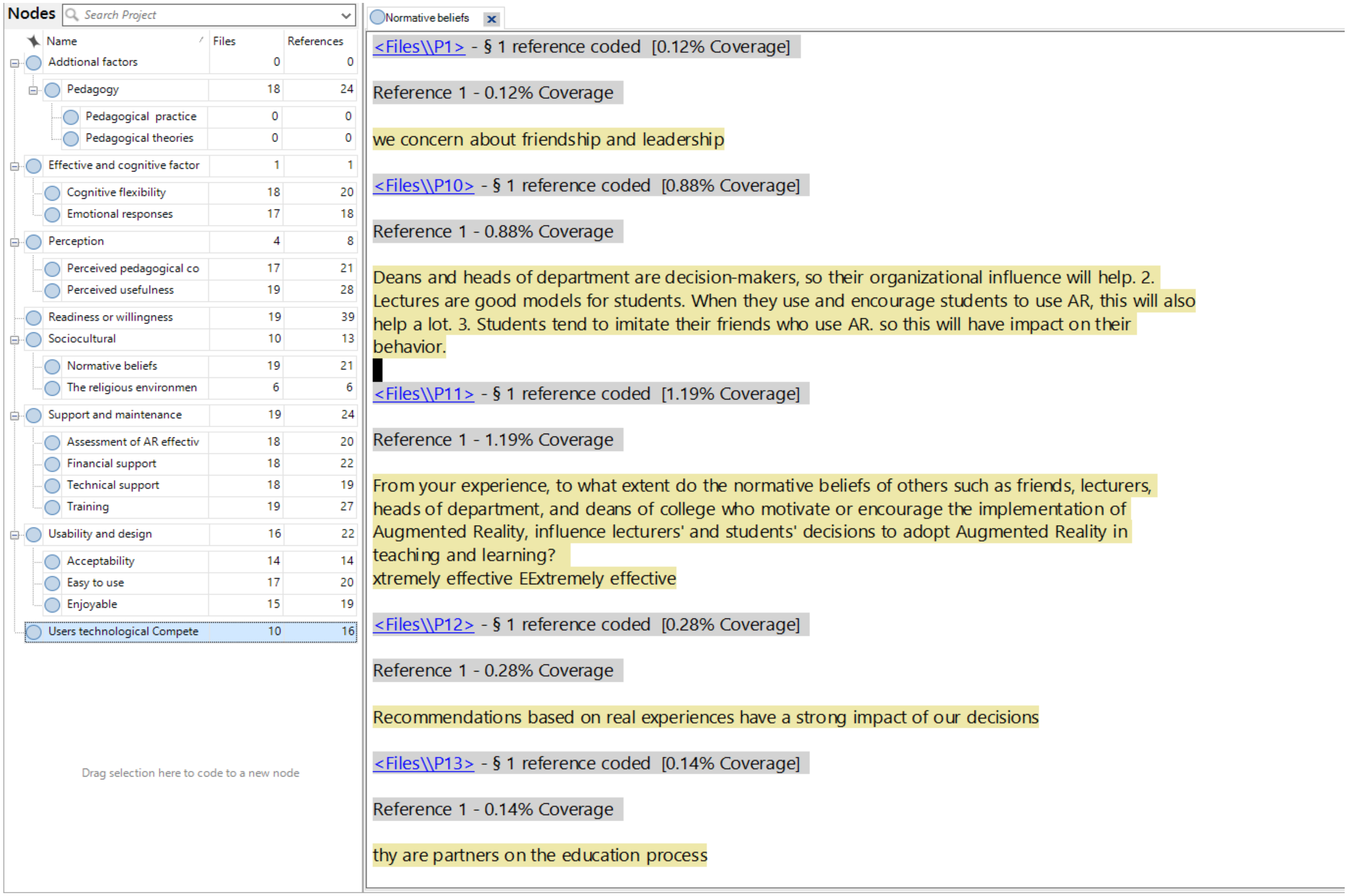


Figure 67. Coded example of the Interview

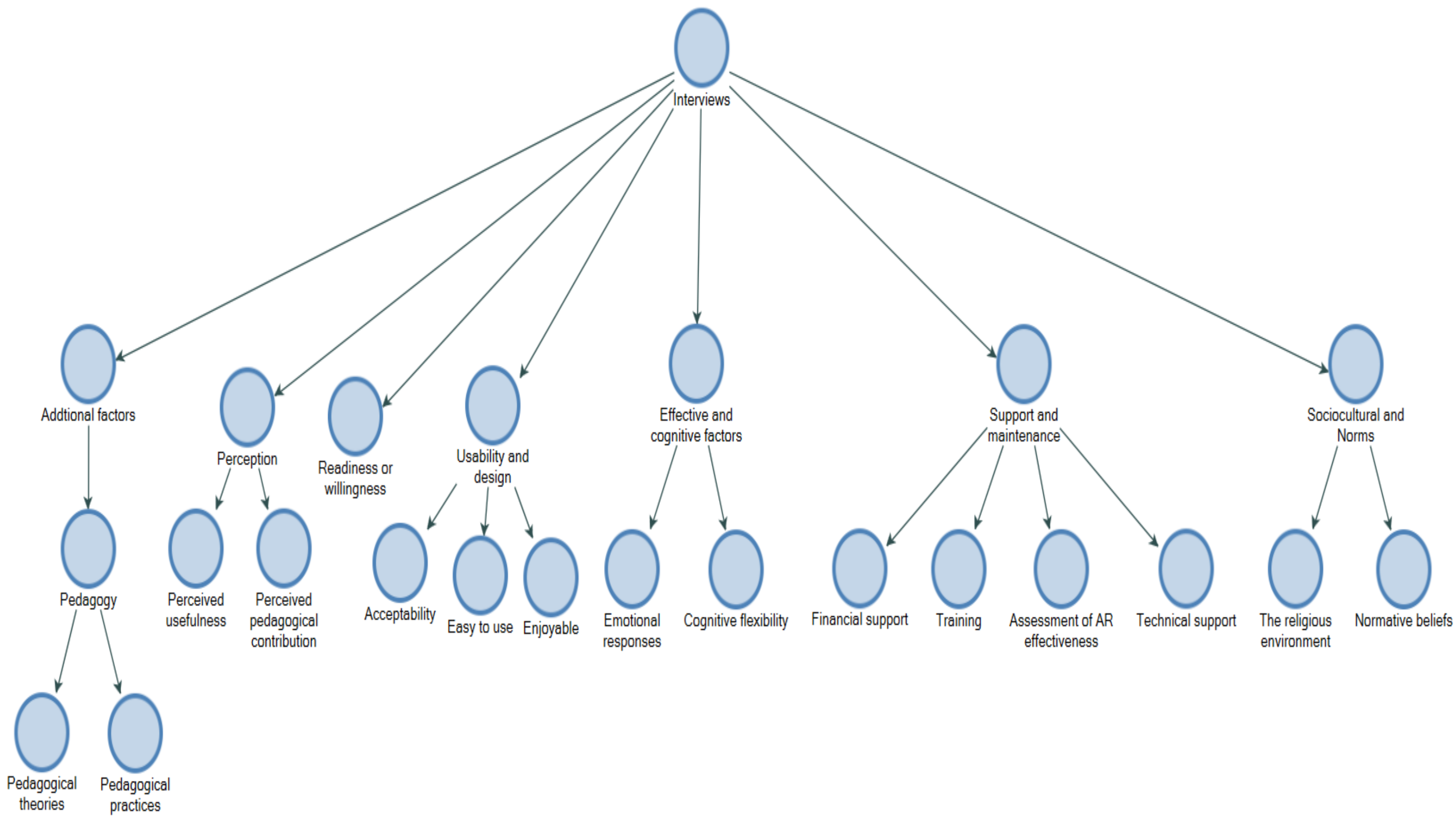


Figure 68: Interview coding tree

5.5 Validity and Reliability

According to Leung (2015, p. 325–326), “Validity in qualitative research means ‘appropriateness’ of the tools, processes, and data”. Whereas “reliability refers to exact replicability of the processes and the results.” During the design of the study, analysis of results and assessment of study quality, validity and reliability are two essential factors that need to be considered by the qualitative researcher (Golafshani, 2003). In this study, the researcher applied online SSI with open-ended questions that provided study validity and trustworthiness by permitting the interviewees (Harrell & Bradley, 2009) to provide information in detail and depth and express their views and experiences on a topic.

As mentioned in section 3.3.3, to have a robust interpretive aspect, a mixed-methods approach was adopted in this study to increase validity and collect information from different phases. The literature was reviewed to develop the conceptual framework. An enhanced AR framework was then produced after interpreting the second results from the factor analysis. Finally, interviews were conducted to ensure that it was done in a trustworthy and credible manner. Moreover, for validity and reliability purposes, the following decisions were made to ensure the interviews themselves were credible and trustworthy:

- Semi-structured interview with open-ended questions was applied.
- A pilot study was conducted to ensure credibility, and the interview questions were discussed with participants at the end of the interview. Suggestions were addressed accordingly.
- The researcher examined the data continuously and compared them with the themes to refine meanings.
- As saturation was achieved, no more interviews were conducted.
- To distinguish between researcher words and the words of the respondent, the researcher wrote interviewees’ comments in italics and between bracketed quotes.

5.6 Interpretations and Results

This section demonstrates the interview findings from the 19 interviewees who worked in different universities and industries relevant to AR technology integration in SA universities. The researcher aimed, via these interviews, to go beyond just the survey findings to explore the educational AR experts' perceptions for more in-depth information around factors that contribute to AR adoption and which must be included in the AR framework in Saudi higher education.

The interviews were designed to illustrate the interviewees' views on using AR technology in Saudi universities. The interviewees were asked flexible questions within an organised framework. In the first set of questions, interviewees were asked questions to encourage them to talk about themselves, their experiences, opinions, thoughts, and their history.

The second set of questions focused on examining interviewees' experiences by asking open-ended questions concerning integrating AR technology into the Saudi education context and elicit extra factors. Reja et al. (2003) asserted that open-ended questions could be utilised to obtain new and useful information and encourage new concepts to emerge through intense and in-depth discussion. According to Collis et al. (2003), data collection that is rich in detail and analysis empowers the validity of the study. The Semi-structured interview questions included asking the research interviewees 18 questions (please see Appendix 4) that were divided into four sections, as illustrated in Figure 69:

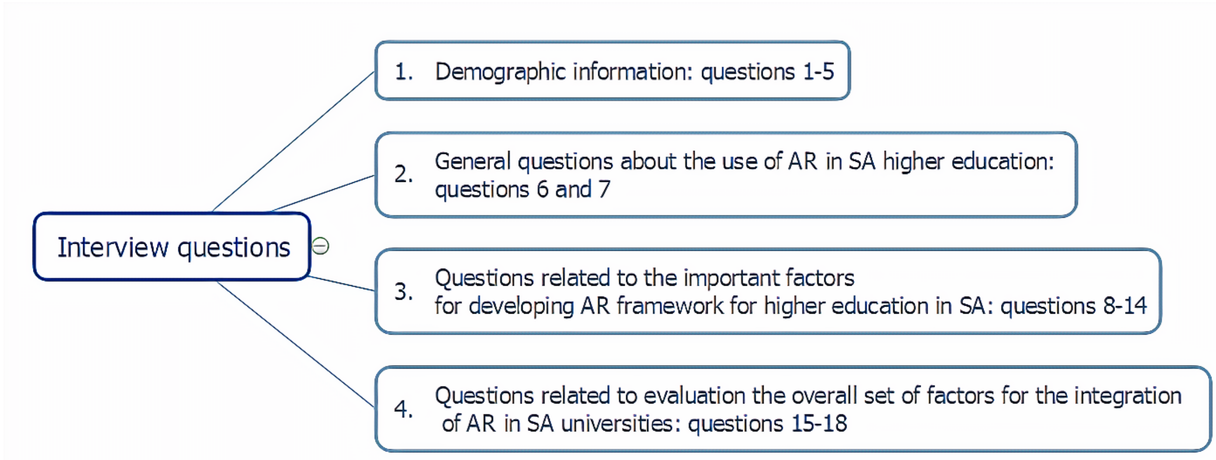


Figure 69. Interview sections

5.6.1 Demographics Questions

Demographics questions are the first part of the interview, and this section identified the demographic and descriptions of the interviewees. The demographics information included: age, degree, years in their current job and experience with AR technology. Table 60 illustrates the analysis of the demographics' questions.

Table 60: summary of participant demographic information

Demographics items	Categories	Frequency	Percentage
Age	20–30	1	5.26%
	31–40	8	42.11%
	41–50	9	47.37%
	51–60	1	5.26%
	More than 60	0	0.00%
	Total	19	100%
Degree	PhD Degree	12	63.16%
	Master's degree	6	31.58%
	Bachelor's degree	1	5.26%
	Total	19	100%

Demographics items	Categories	Frequency	Percentage
Years in the current job	Less than 5 years	5	26.32%
	5–10 years	9	47.37%
	11–15 years	3	15.79%
	16–20 years	0	0.00%
	21–25 years	2	10.53%
	Total	19	100%
Experience with AR technology	Extremely competent	5	26.32%
	Somewhat competent	10	52.63%
	Neither competent nor incompetent	4	21.05%
	Somewhat incompetent	0	0.00%
	Extremely incompetent	0	0.00%
	Total	19	100%

Nineteen respondents provided answers to the interview questions. Most of the interviewees' (47.37%) age ranged from 41 to 50, while the rest of the interviewees' ages was distributed from 20 to 40. Regarding the educational degree, most of the interviewees (63.16%) had a PhD Degree. The second-largest group was that of master's degree holders (31.58%). Only one of the interviewees had a bachelor's degree.

The interviewees were asked to provide information about the number of years they had worked in their current job. The interviewees were generally spread between the different years of experience in their current job. Those who had worked for five to ten years were the most highly represented by the interviewees, accounting for 47.37%, followed by those who reported working for less than five years. Interviewees who had worked for 16 to 20 and 21 to 25 years were the least represented among the interviewees comprising 10.35%.

Interviewees were also asked to indicate their experience with AR technolo gy. The results from 19 responses showed that ten interviewees (or 52.63%) were competent with AR technology, followed by those who reported being extremely competent (26.32%), while four (21.05%) noted that they were neither competent nor incompetent. The majority of the interviewees who responded and conducted the interview questions were males (16 out of 19), whereas, after several attempts to reach female interviewees, only three females completed the interview. The gender roles imposed on Saudi nationals resulted in only a small group of female interviewees, as their involvement was difficult to achieve.

The interviewees' descriptions and experiences with AR technology are briefly provided in Table 61.

Table 61: Interviewees and their descriptions

Interviewees	***Gender***	***Qualification***	***Work Experience AR***	***Current Job***
Participant 1 (P1)	Male	PhD candidate	He has been a group member of Virtual and Interactive Simulations of Reality for around four years. He is doing his research particularly in developing AR, and he has a competent level of knowledge and experience of AR technology.	Lecturer at one of the Saudi universities.
Participant 2 (P2)	Male	PhD candidate	He has developed some AR apps for a research purpose and holds an extremely competent level of knowledge and experience of AR technology.	Lecturer at one of the Saudi universities.
Participant 3 (P3)	Male	Professor	Specialist in MIS, Project Management Consultant Others e-Learning, web programming, web design, and e-commerce. He is interested in research and technology and lectures about AR technology with a competent level of knowledge and experience of AR technology.	• Professor at one of the Saudi universities. • Associated Professor of Management IS. • Dean for E-learning. • Vice Dean for administrative and financial affairs at E-learning Deanship. • Project manager of Leaning Management Systems (LMS) and Digital Courses.
Participant 4 (P4)	Male	PhD degree	He has supervised projects and did some work related to AR technology in one of SA's universities. P4 has experiences in E-Learning, Designing, Design Thinking, User Experience, Prototyping, Usability, Human-Computer Interaction, User Studies, and Human-Machine Interaction. He has a competent level of knowledge and experience of AR technology.	Dean of CCSIT. • Associate Professor at College of computer sciences and IT • Chairman IS department • Dean, College of computer sciences and IT
Participant 5 (P5)	Male	Master's degree	He has used AR technology in some domains with a competent level of knowledge and experience of AR technology.	E-Learning General Coordinator in English Department - Prep Year at one of SAn Universities.

Interviewees	***Gender***	***Qualification***	***Work Experience AR***	***Current Job***
Participant 6 (P6)	Female	PhD Degree	She has launched an initiative AR technology and hosted the deans of colleges at the university. Her team explained the technology to the deans of colleges and expressed their admiration and enthusiasm for using this technology. She has an extremely competent level of knowledge and experience of AR technology.	E-learning staff and developer at one of SA Universities. • Founder at E-learning Innovations Company. • Assistant professor /Department of European Languages. • Head of the Development Department in deanship of E-learning and Distance Education. • Deputy Vice President for Strategic Planning Unit Faculty of Arts and Humanities/Girls' Colleges Branch. • Head of the Department of E-Learning Programs.
Participant 7 (P7)	Male	PhD candidate	P7 has a competent level of knowledge and experience of AR technology via searching the use of AR in many sectors including games, architecture, medicine and some areas of education.	A lecturer and previous E-Learning General Coordinator in computer science Department - Prep Year in one of SA universities
Participant 8 (P8)	Male	Master's degree	P8 provides readymade e-services and training, customised IT solutions and training, innovative, secure services and solutions to both public and private sectors in SA, including higher education. He has a competent level of knowledge and experience of AR technology.	Project manager at IT and Services company.
Participant 9 (P9)	Male	PhD Degree	P9 has an extremely competent level of knowledge and experience of AR technology through experimenting with AR apps either to design educational or marketing experiences Since 2014.	Head of development dept/deanship of E-learning and distance education. • Director of the Design Centre • Dean of E-Learning • Deputy Dean of E-Learning • Deputy CIO - IT Infrastructure Management

Interviewees	*Gender*	*Qualification*	*Work Experience AR*	*Current Job*
Participant 10 (P10)	Male	PhD Degree	P10 has an extremely competent level of knowledge and experience of AR technology. He uses AR as an innovative teaching technique that integrates technology in learning English as a foreign language in higher education. Two years ago, he used AR applications to teach reading comprehension.	Head of Curriculum and Educational Technology.
Participant 11 (P11)	Male	Bachelor's degree	P11 is working as a VR developer. He has a competent level of knowledge and experience of AR technology through Developing apps using Unity a Vuforia. Develops apps in Microsoft HoloLens, Vuzix and mobile.	Software Engineer at a company.
Participant 12 (P12)	Male	PhD Degree	He has a competent level of knowledge and experience of AR technology by designing an AR application two years ago. He has experience in his current job with 11 – 15 years.	E-content development manager.
Participant 13 (P13)	Male	PhD Degree	P13 has an extremely competent level of knowledge and experience of AR technology. He is using this technology since 2013 in deanship of e-learning and distance education. P13 has experience in his current job with 11 – 15 years.	Director of the operation of e-learning programs in one of SA's universities.
Participant 14 (P14)	Female	PhD Degree	P14 is neither competent nor incompetent with AR technology. She has experience in her current job with 5 – 10 years.	She is working on educational projects department in deanship of E-Learning and Distance Education at one of the SAn universities.
Participant 15 (P15)	Male	PhD Degree	P15 has a competent level of knowledge and experience of AR technology after trying it with his students as a tutor during his PhD study. He has experience in his current job with 5 – 10 years.	Assistant Professor of TESOL & M-Learning at in one of SA's universities.

Interviewees	*Gender*	*Qualification*	*Work Experience AR*	*Current Job*
Participant 16 (P16)	Female	Master's degree	She is working with a team of experienced in Mobile Applications, Android App Development, iPhone App Development, e-Learning, E-Learning Consulting, Design, Development and Implementation. P16 has a competent level of knowledge and experience of AR technology. She used the Aurasma app in one class requesting from the students to present their ideas using Aurasma. She has experience in her current job for less than 5 years.	Lecturer at one of the Saudi Universities and E-Learning Consulting.
Participant 17 (P17)	Male	PhD Degree	P17 has a competent level of knowledge and experience of AR technology as a researcher. He has experience in his current job with 5 – 10 years.	Vice Dean of E-Learning Deanship at one of the Saudi Universities.
Participant 18 (P18)	Male	Master's degree	P18 is currently developing various applications using AR. These are mostly for schools and Universities and mostly for learning aids as AR-enabled textbooks and hands-on exercises. P18 has an extremely competent level of knowledge and experience of AR technology. P18 has experience in his current job for more 24 years.	Vice President– Projects & Technology Development in Educational company.
Participant 19 (P19)	Male	PhD Degree	P19 has a competent level of knowledge and experience of AR technology by attending some workshops on AR and has used this technology on one of his courses in image processing. He has experience in his current job with 5 – 10 years.	Assistant professor one of Saudi Universities.

5.6.2 General Questions about AR Use in SA Universities.

The researcher asked the interviewees various general questions concerning their perspective and experience about the integration of AR in SA higher education. These included:

- What is your opinion about incorporating AR technologies in Saudi universities?
- What are the important factors that should be considered before incorporating AR into teaching and learning at SAn universities?

Of those interviewed, 100% agreed with implementing and introducing AR technology into SAn higher education. Each interviewee revealed similar opinions about introducing AR technology in SA higher education, and almost all of them made the same point, which is that SA has the infrastructure required to use this technology. Reasons for this included the vision of SA 2030 encourages the knowledge economy, and the government supports the new technologies, especially in education.

> **P1** stated that *"Saudi universities have great support from the Saudi government. The government is looking at developing lots of sectors via research groups at universities. So, I believe that it is possible to introduce this technology to Saudi universities."*

> **P7** stated *"availability of needed infrastructure—Universities in KSA are always looking to improve the educational process and facilitate and use the different technologies that can enhance the learning process. Students in SA have motivations in using new technologies. Financially, Saudi universities can introduce this technology."*

> **P18** stated "*For the past two years or more, Saudi Universities have been getting an introduction to AR (also VR) and we have already demonstrated this in a few universities here. There is a great interest for AR-enabled curriculum here.*"

It was noticeable that all the interviewees, throughout their experiences with educational approaches such as AR, believe that the introduction of AR in SA universities is welcomed by education policy and government support as well as the new generation of SA. This related to the third research question on what are the perceptions towards integrating augmented reality from the educational AR experts' point of view?

In addition, question seven focused on factors that promote or encourage incorporating AR into teaching and learning at SAn universities. Therefore, comparing the responses to this interview question and those given to the survey questions helped to obtain a better understanding of the phenomenon. Interviewees were asked a question about factors that can help to incorporate AR to gain a wide range of possible responses. The question was: "What are the important factors that should be considered before incorporating AR into teaching and learning at SAn universities?" This related to the research question on what factors must be included in the AR framework for higher education in SA. Responses to question 7 illustrated some of the critical factors that might facilitate the adoption of AR in SA universities based on the experts' opinions, such as infrastructure, awareness, training, cost and availability. Some of the interviewees argue that all universities needed to raise awareness about this technology and prepare firm plans to adopt this kind of educational technology. For example, **P6** believed that *"Providing proper training, selecting the areas where this technology is really required to value its use and increasing awareness about this technology."*

Other interviewees stressed the essential factors related to universities support and technology-related factors. The interviewees' comments are illustrated below:

"1. Equipment of hardware such as computers, networks. 2. Training faculty members in using AR in teaching. 3. Adjusting the curriculum to fit AR. 4. Designing AR applications suitable for subjects. 5. Encouraging students to use AR as a culture". **(P9)**

"The university readiness regarding the technical infrastructure, ICT competences of the faculty members and instructional design aspects." **(P11)**

"Infrastructure preparation and preparing qualified teachers to work with this new technology." **(P13)**

Tellingly, however, two interviewees note factors focused on problems related to cultural issues and religious factors.

"Cultural and religious factors should be taken into consideration. The use of a female character for male students is a sensitive issue." **(P4)**

"Only the cultural issues in the produced material". **(P19)**

5.6.3 Factors for Incorporating AR into SA Universities

This section demonstrates the respondents' comments about the essential factors for incorporating AR into SAn universities to determine whether these factors influence the adoption and to attain more information about these factors. It will discuss the seven factors illustrated in section 4.8 yielded from the surveys and was validated through interviews. Most of the interviewees' comments show that the use of AR is a great addition to higher education, but many factors will influence the adoption. These factors include sociocultural factors and norms, perceived usefulness, perceived pedagogical contribution, readiness or willingness, usability and design, support and maintenance, pedagogy, and affective and cognitive factors.

5.6.3.1 Sociocultural Factors and Norms

From the review of literature on sociocultural factors and norms, as discussed in section 1.8.1, the education system in SA is guided by Islamic culture, and cultural background significantly influences the design and incorporation of new technologies. The interviewees were also asked about the sociocultural factors that encourage or limit the integration of AR system in Saudi universities. Following the different results from students and faculty members' surveys, both surveys showed different opinions about the sociocultural factors. These questions aim to further measure the influences of these factors on the adoption of AR by SAn universities.

- ***The cultural and religious environment***

From the interviews, it was observed that there were different opinions about culture and religious factors among interviewees, some of the interviewees agreed on the importance of this factor (11), and the other did not agree (eight). The interviewees also were asked to rate the importance of sociocultural factors. Over half of the interviewees (53 %) rate sociocultural factors as an essential factor to be included in the AR framework for SA universities. Figure 70 below illustrates the interviewees' responses regarding the importance of sociocultural factors and norms.

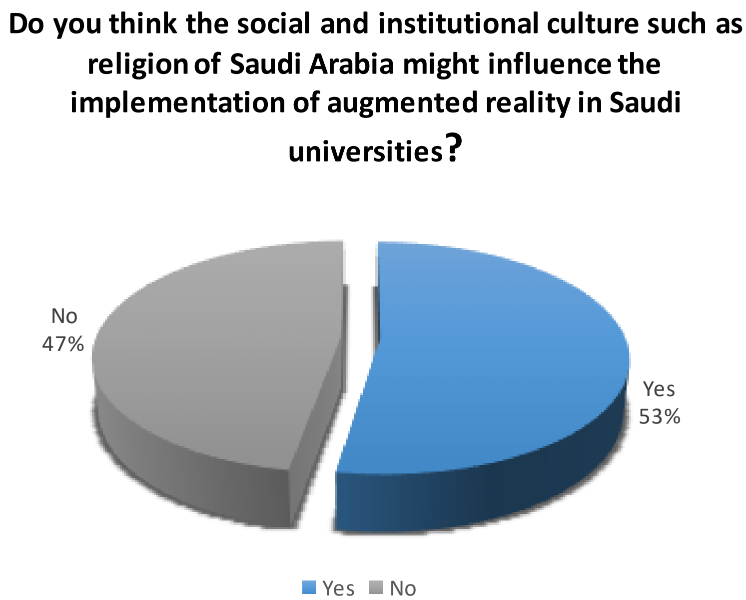


Figure 70. Interviewees' responses on the influence of the sociocultural factor

The comments of the interviewees who agreed that sociocultural factor is essential and these findings correspond to the findings from the survey. More than half of the interviewees felt that there was a need for considering sociocultural factors. The interviewees' comments are illustrated as the following:

> *"The use of a female character for male students is a sensitive issue. Cultural and religious factors should be taken into consideration."* **(P5)**

> *"The religious environment may influence the implementation of AR since this technology may have some negative effects on students such as pictures of women, signs that contradict with people's religious beliefs."* **(P10)**

"Every wave in technology starts with the impact of social and institutional cultures; that is how it spreads all over the society." **(P16)**

On the other hand, the interviewees indicated the reasons for disagreed with the importance of sociocultural factors by the following comments:

"I do not really think that this can be a great issue as this can be maintained as long as it is used appropriately and for the intended use. But anything that will be against cultural issues will be highly rejected. This applies to all different smart technologies. It might influence the implementation as this is the case in any place with its policies and rules. I think that once it is clear to the decision-makers, there is going to be no problems. Any new idea to be implemented needs understanding first. From my experience, I do not think that there is going to be major difficulties in implementing it." **(P7)**

"My initial answer was 'I do not see the relevance of religion to this!' Probably, you are considering AR design stages which involve image tracking using cams? Which can offend people! I really cannot see the relevance of religion! Ok, I think you are considering AR games like Pokémon Go where the user is using AR for entertainment purposes hence might go against a few social or cultural norms or even be a threat to his environment. I can say that as you are researching the use of AR in educational settings, then you might as well understand that using AR will be for instructional purposes and even if you considered AR games for education then again "education" is the keyword hence the controlling principle..." **(P9)**

> *"I think that there is no direct relationship or no conflict between the religious environment of SA and implementing the augmented reality in universities Vision of the Kingdom 2030 and the trend towards development in all fields especially the field of education, with the emphasis again on that there is no conflict between the social and institutional culture of SA and the implementation of Augmented Reality in Saudi universities."* **(P14)**

- ***Ethical concerns***

Of the sub-factors, most of the interviewees disagreed that using AR in SA universities would raise ethical concerns. They believed that AR technology as an educational tool does not contradict with the ethics of the community:

> *"If all factors were considered carefully, the ethical aspect will not be an issue."* ***(P5)***

> *"I cannot think of ethical concerns of relevance to the use of AR for educational purposes."* ***(P9)***

> *"I do not think the introduction of any new technology platform into SA makes such concerns. Students here are ready to adopt any technology that they find interesting and helpful"* ***(P15)***

- ***Personal normative beliefs***

According to Ajzen's (2011) Theory of Planned Behaviour, normative beliefs arise primarily from subjective norms, which are formed as a result of social encouragement, enticement and pressure. Of the sub-factors, the researcher discovered that 17 of the interviewees (please see Figure 71) agreed that the normative beliefs are practical factors to incorporate AR technology in SA universities.

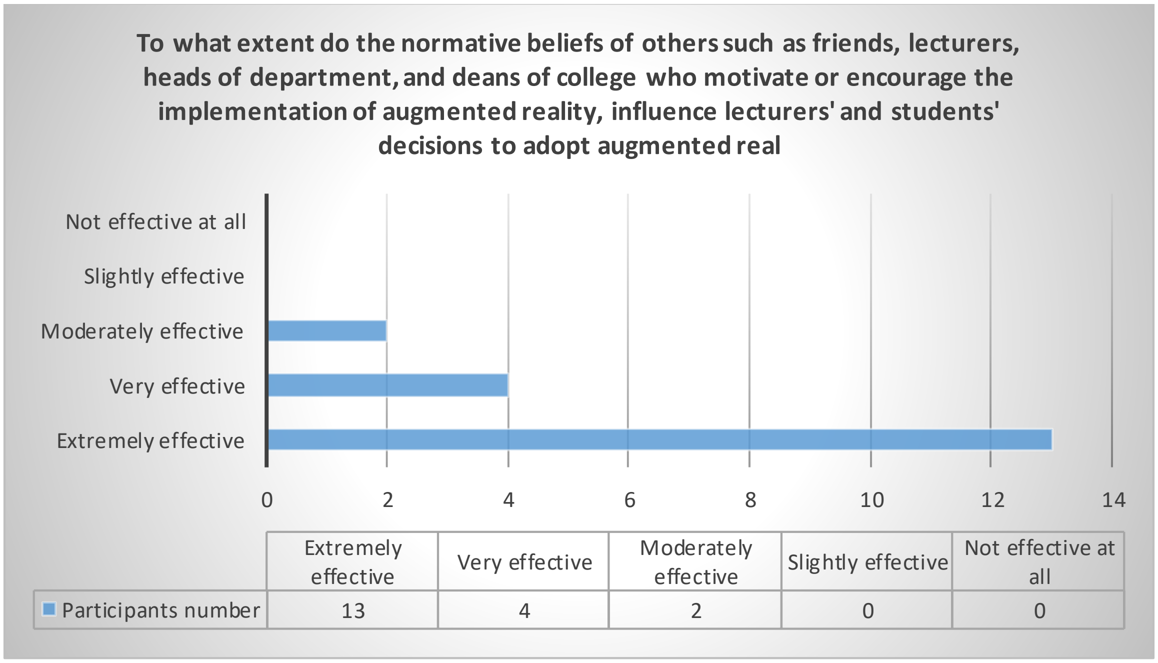


Figure 71. Interviewees' rate on the influence of normative believes in the adoption of AR

The following comments illustrate this:

> *"In SA, we are concerned about friendship and leadership. Encouragements that come from close friends or employees with higher positions highly influence the adapting and using the augmented reality in the educational system…."* **(P1)**

> *"Adoption of any technology in an educational setting is always strategically driven; hence an educator who is trying to use any technology is constantly looking for validation for his practices from the university leaders."* **(P8)**

> *"1. Deans and heads of department are decision-makers, so their organisational influence will help. 2. Lectures are good models for students. When they use and encourage students to use AR, this will also help a lot. 3. Students tend to imitate their*

friends who use AR. so this will have an impact on their behaviours." **(P9)**

"From my experience, students needed support from both institutions and relatives to adopt Blackboard tools into their learning experience." **(P14)**

As a result, most of the interviewees support the influence of sociocultural and norm factors to be added to the AR framework for SA universities. There were mixed views about the religious influence in SA. Some believe that the religious environment in SA will embrace AR technology especially after the new trends towards modern Islam and they think SA reached a stage where they could say that religious beliefs and environment will not restrict the development of the country, specifically with the announcement of the new Vision 2030. Others stressed the importance of the religious factor. Thus, these factors were integrated into the final AR framework for SA universities. The interviewees agreed that contextual-related factors such as culture, including the religious environment and normative beliefs, influence the adoption of AR in SA universities.

Ethical concern items were removed from the framework because most of the interviewees believed that issues such as ethics would not hinder the implementation of AR, and it can be controlled as any other regular technology. These are summarised in the concept map in Figure 72.

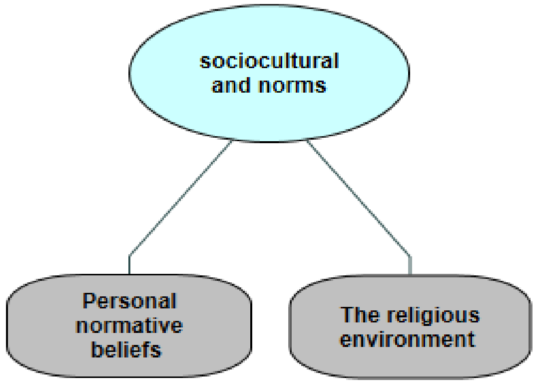


Figure 72. Concept map illustrating sociocultural and norms factors

5.6.3.2 Perceived Usefulness

This factor mainly focuses on the perception and awareness of using AR technology in higher education and includes perceived usefulness. This factor is considered an important indicator that influences the intention to integrate AR in teaching and learning, as described in detail in section 2.9.2.

The usefulness factor is further emphasised by the response that the interviewees would adopt AR technology when there were awareness and positive perception towards the value of AR. It appeared from the interviews that all interviewees agreed with the importance of this factor as they believed that if educators did not perceive the value and usefulness of using AR, they would not adopt it. Figure 73 below illustrates the respondents' thoughts about the importance of this factor.

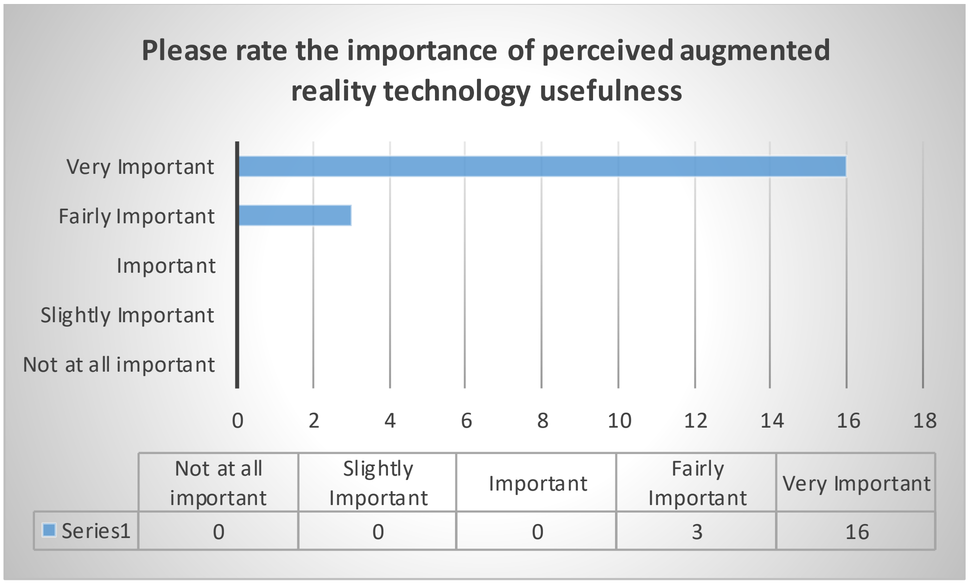


Figure 73. Interviewees' agreement on the importance of the perceived usefulness factor

Interviewees, therefore, support the perception of AR usefulness factor, which might impact the educators' willingness to enhance their instructional design to incorporate AR experiences as the following comments:

> *"Awareness of its usefulness and how to later integrate it is important. Once this technology is used after increasing awareness and providing required training on its use, its integration will become required to mostly benefit from it."* **(P7)**

> *"When faculty members perceive the usefulness of AR, they will: 1. Encourage students to use this technology effectively. 2. Advise students in using AR in specific situations. 3. Help students use the appropriate application(s). 4. Design their application(s). 5. Convince decision-makers to adopt AR. 6. Raise students' attitudes towards using AR."* **(P10)**

> *"Teachers and students need to understand the power of this technology and build their knowledge of creating useful material to help students to accept this technology."* **(P14)**

> *"The introduction of any new technological trend into learning should be preceded by students' awareness of the potential of such technology, and why they should be using it for learning purposes, and what are the outcomes of it."* **(P15)**

To sum up, the importance of the perceived AR usefulness factor was confirmed by 100 per cent of the interviewees. Therefore, this factor was included in the final AR framework for SA universities. All the interviewees suggested that perception of the usefulness of such technology increases the opportunity to adopt it.

5.6.3.3 Perceived Pedagogical Contribution

As discussed in section 2.3.5.7, pedagogy is about the practice of teaching that deals with theories and how these enhance student learning outcomes. The awareness of and belief in the pedagogical contribution of new technologies in education will encourage the acceptance of AR in higher education. Most often, the problem is not the acceptance of new technologies by faculty members and students in teaching and learning, but lack of awareness of the pedagogical benefits (Bower et al., 2016).

As can be seen in Figure 74 below, most of the interviewees agreed that the perception of pedagogical contributions among teaching staff and educational policymaker plays a crucial role in the successful implementation of AR technologies.

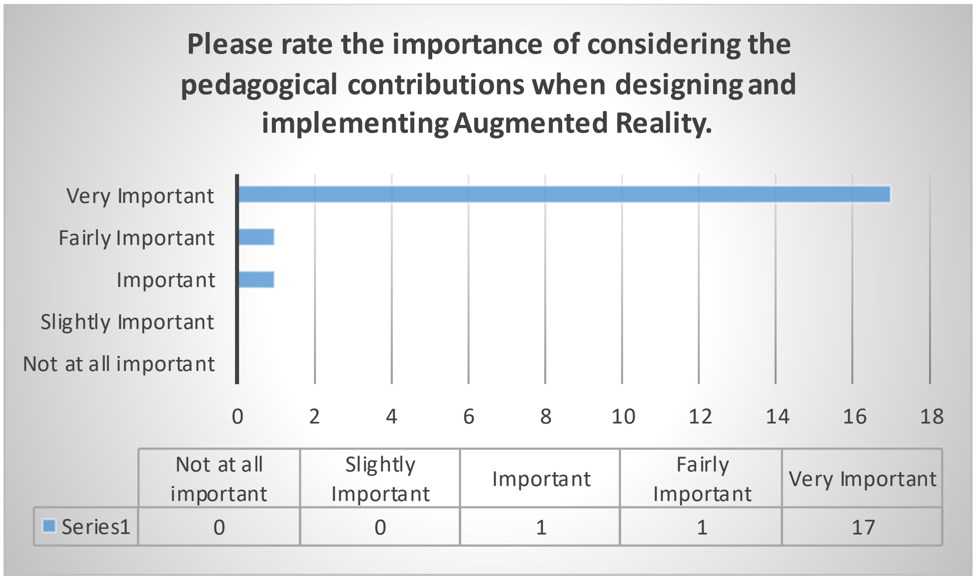


Figure 74. Interviewees' agreement on the importance of the Perceived pedagogical contribution factor

Below, quotes from the transcripts provide some interviewees' opinions on this factor:

> *"Nowadays, we need major changes in pedagogies to be in line with the latest developments. This technology can have a huge contribution in this regard."* **(P4)**

> *"The perceived pedagogical contributions of any new educational strategies or science are essential to facilitate their adoption"* **(P5)**

> *"Pedagogical contribution of any educational technology has the power to influence the acceptance of these technologies by all stakeholders"* **(P8)**

> *"..... We need to raise awareness for the pedagogical capabilities of this technology among Doctors and the correct ways of using it"* **(P13)**

In brief, most of the interviewees stressed the importance of perceiving the AR pedagogical benefits by raising the awareness of faculty members and decision-makers. It was noticeable that interviewees mentioned several times the factor of perceived pedagogical contributions. In line with their comments, it was proven appropriate to include it in the final AR framework for SA universities.

5.6.3.4 Pedagogy

The pedagogy factor questions were not asked in the survey phases as lecturers and students were not best placed to discuss pedagogy. Therefore, it was asked in this phase because one of the targeted interviewees were educational technology experts. The interviewees in the interview confirmed that it is essential that pedagogical approaches (e.g. learning theories, practices and strategies) be considered when designing and implementing AR in Saudi universities. The interviewees declared that using AR technology as a teaching method should be based on robust pedagogical theories and practices to promote the effectiveness of AR technology. These are summarised in the concept map in Figure 75.

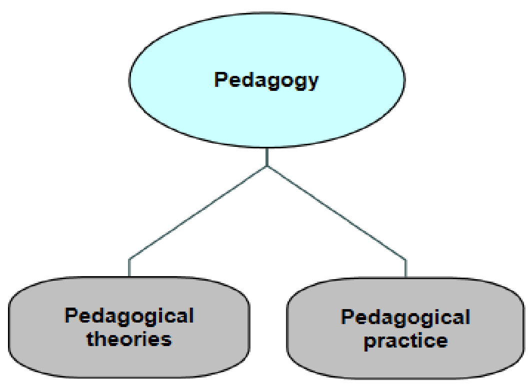


Figure 75. Concept map illustrating pedagogy factor

Some quotes from the transcripts provide some interviewees' opinions on this factor:

"*Almost all educational institutions implement new technologies based on best practices and proven theories. Technology cannot be used, except with a design model followed by a faculty member, teacher or trainer, and it is not possible to start using technology only after considering previous practices. Develop new and better practices that were previously based on research and educational perspectives"* **(P3)**

"before adopting any technology in learning and teaching, the pedagogical principles are needed to be addressed in order to make full use of this technology and change the use of traditional methods" **(P7)**

"As I did a research in students learning styles and its effect on the student performance, the main goal in using AR to be directed in activating the internal motivation in students. Thus, pedagogical approaches such as experiential Learning in AR environment need to be implemented to ensure this learning occurs." **(P12)**

".... any teaching tool should be aligned with the pedagogical approaches. It is important to take care of the pedagogical side because it will be used in an educational environment which deals with various sciences and different types of students, therefore, must take into account the pedagogical aspect of education to achieve benefit" **(P19)**

As seen in the comments above, all the interviewees emphasised the significance of selecting appropriate pedagogical strategies such as learning theories and learning styles, when incorporating AR technology to ensure the effectiveness of this technology in SA universities. Hence, based on the interviewees' opinions, an additional factor was named pedagogy and incorporated into the final AR framework for SA universities.

5.6.3.5 Readiness and Willingness

To establish a coherent and possible strategy to adopt AR systems in universities, technology readiness is required. Readiness is related to people's tendency to adopt and utilise new technologies to achieve objectives in home and work life. Readiness could be done through raising the awareness, providing special workshops for students and lecturers, and well-built infrastructure (the readiness factor is discussed in detail in section 2.9.2).

The interviewees believed that readiness is an essential part of the adoption process, and 95% of the interviewees agreed on the need for this factor (please see Figure 76).

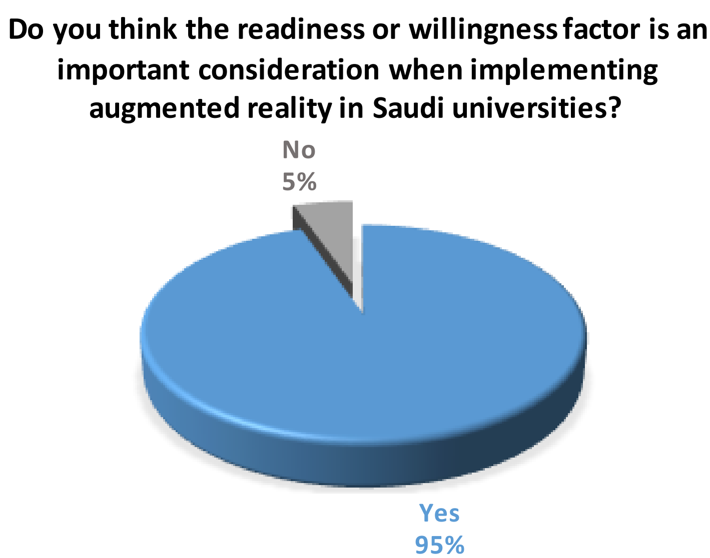


Figure 76: Interviewees responses on the importance of the readiness and willingness factors

As supported by the following comments:

> *"Yes, the readiness of the organisation and its willingness to embrace modern technology in higher education is one of the*

most important indicators for the success of their implementation. It is highly important; this will be increased by awareness and training in addition to including it as a factor of evaluation where appropriate." **(P6)**

"When decision-makers and instructors are not willing to use AR, they will not help in active implementation of AR. Non-motivated staff will not have the desire to adopt AR. Readiness is the most important factor if we going to apply new technology." **(P7)**

"Yes, both students and teaching staff need to be familiarised of such technology and how it would make a difference in education." **(P12)**

"Yes, it is I think one of the most important factors. Willingness and training to staff in the organisation can facilitate the integration of AR. In SA, the youth are willing to adopt new technologies compared to the elderly generation where they resist the change and the adoption of new technology." **(P19)**

Some interviewees declared that students and academic staff are willing to adopt AR in Saudi universities:

"The majority of Saudis are willing to use and discover new technologies. We should take this advantage and try to implement applications that are suitable for these people to easily involve them with technology." **(P1)**

> *"I believe that most Saudi university students and faculty members, especially the new generation, are ready and interested in modern technology"* **(P9)**

> *"The students I believe, will be more motivated to use AR compared to the academic staff whom the majority of them do not like to expand their teaching methodology and integrate new technologies in their teaching."* **(P19)**

In short, all respondents confirmed the readiness factor and verified the contribution of readiness and willingness in influencing the adoption of AR in SA universities. This factor is, therefore, included in the SA Universities' final AR framework.

5.6.3.6 Usability and Design

As discussed in section 2.9.5, the AR system includes extensive interaction with the user, and therefore the usability factors must be addressed. AR must be appropriately designed to be used and match users' needs and skills. The design of the content and applications of AR must ensure ease of use by both staff and students and must be free from the errors and potential difficulties that users may encounter during teaching and learning sessions.

Based on thematic analysis of the data, this factor depends on critical dimensions which might promote the full acceptance and adoption of AR in higher education: acceptability, being easy to use, and enjoyable. These are demonstrated in Figure 77.

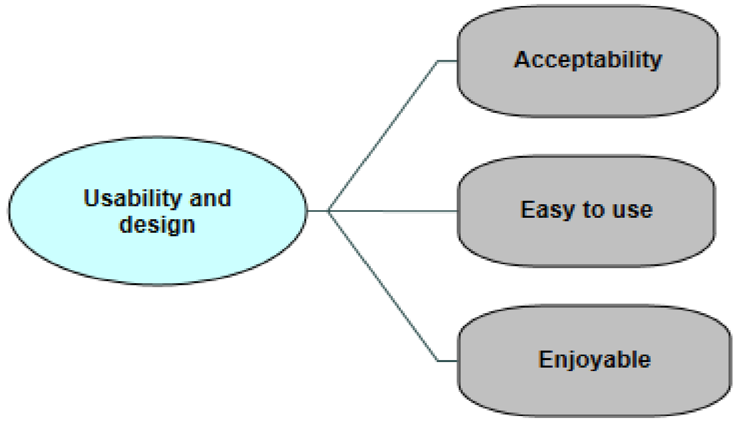


Figure 77. Concept map illustrating usability and design factors

- ***Acceptability***

Acceptability is related to the issues that affect users' willingness to use AR applications during the learning process. Arthur (2009, p. 29) defined acceptability for technology as being a "means to fulfil a human purpose." AR acceptability by the faculty members and students is needed to be considered in AR integration to ensure the quality of AR in the teaching and learning process. The quality and acceptability of AR content design were cited by many interviewees as an indicator to encourage AR use and adoption, as demonstrated by the following comments:

> *"If the designer does not consider the usability of the provided content, the user then will hesitate to use the system, particularly with expert users who always deal with various applications. The users are not ready to waste their time using a new application that does not provide an easy way to reach the users' goals."* **(P1)**

> *"It has to be designed properly to be used."* **(P2)**

> *"Most of the introduced technologies in higher education in Saudi need more time to be accepted. Lecturers and students*

need more time to adapt to new technology. On the other hand, students might find AR more interesting as youth usually are looking for getting new experiences" **(P8)**

"Suitable AR applications are not available all the time, so designing of AR application is crucial. When academic staff are not able to use AR, it will be useless." **(P9)**

- ***Easy to use***

Another usability dimension is easy to use. The emphasis placed by interviewees on the need for easy to use AR applications by both faculty members and students to encourage a positive attitude and willingness towards this technology. Sample quotes are shown below:

"Complicated design and difficult use of AR will lead to frustration and neglecting technology in education. Therefore, AR needs experts to design easy to use applications for both students and teachers. For example, students and lecturers did not use Blackboard in the beginning due to its layout complexity." **(P8)**

"The flexibility of using this technology is important…." **(P13)**

"It is important as we have tried previously to incorporate some systems within the university, and they have failed due to the complexity of the design. Both students and lecturer struggled to get used to the new system, which then leads both to abandon the newly incorporated system." **(P19)**

- ***Enjoyable***

Several interview interviewees reported their opinions in using AR in education as an enjoyable experience. They believed that the enjoyment of using the AR system is a predictor of AR adoption. The interviewees indicated that the design of AR applications in education have to be enjoyable for the students. Sample quotes are shown below:

> *"I think lecturers and students in Saudi universities will accept AR technology in the teaching and learning process because it is enjoyable."* **(P5)**

> *"AR helps me to release tension. Using AR is exciting. Using AR is a worthwhile activity. The materials presented using AR are eye-catching. Using AR helps me to develop useful skills. Using AR allows students and teachers to enter a fantasy world."* **(P9)**

> *"It is important for the usability and design of AR to attract students."* **(P5)**

Some of the interviewees raised concerns about designing the content of AR material in their comments. AR content design was considered a difficult task for teachers and students, which might influence the embracing of AR technologies in education:

> *"It needs experts in this field. It needs cooperation between teachers, designers, curriculum experts and experts in measurement and evaluation."* **(P9)**

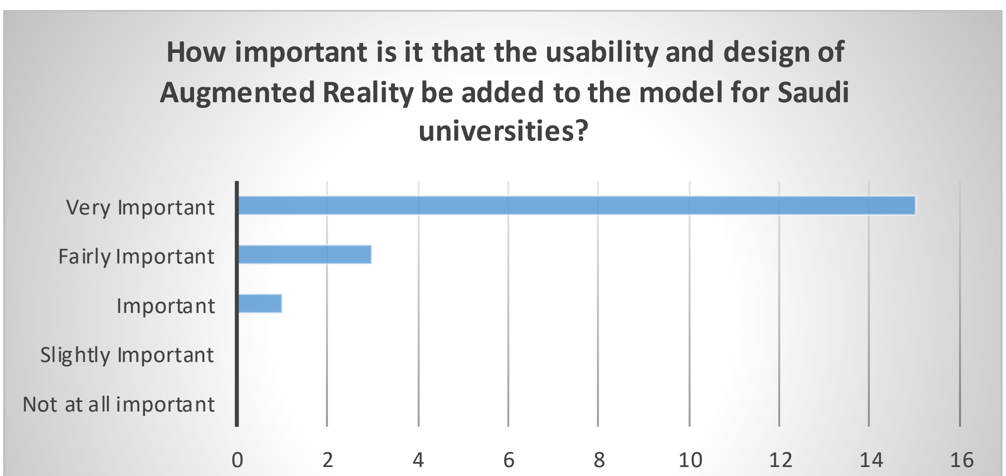
> *"Most lecturers and teachers have low design skills (except those who are already practising instructional design and have instructional technology degree)"* **(P11)**

"This should be done by experts in development. Lecturers and teachers can act as subject matter experts only. This as developing e-content." **(P12)**

"Teachers are not digital natives, unlike students. So, they will need training before implementing any technology for learning." **(P14)**

"It might be a very technical process for them to learn. You have to consider other majors such as art and Islamic teaching majors, and they might not have high technical skills to design suitable content. However, each facility should start on having a department to assess lecturers with the design and delivery of the learning materials." **(P19)**

Hence, Figure 78 demonstrates that all respondents agreed to the importance of the usability and design factors, and they believed that the flexibility of using AR technology is a critical factor in its adoption and acceptance.



	Not at all important	Slightly Important	Important	Fairly Important	Very Important
Series1	0	0	1	3	15

Figure 78. Interviewees' agreement on the importance of the usability and design factors

Also, the consideration of the content designing of AR technology was supported by the respondents as an essential factor that will contribute to AR incorporation in SA universities. Consequently, these factors are added in the final AR framework for SA universities.

5.6.3.7 Support and Maintenance

As discussed in section 2.9.8, having a support and development procedure in place when implementing AR in higher education is a crucial factor to be considered. The implementation of AR has to be supported and maintained to ensure the effective use of this technology in developing countries (Ejiaku, 2014). Several conventional processes for the support and maintenance of AR were identified following thematic analysis. These are demonstrated in Figure 79. Support and maintenance processes include enough financial funding for development plans, technical support, training, and monitoring the impact and use of AR in the learning and teaching process.

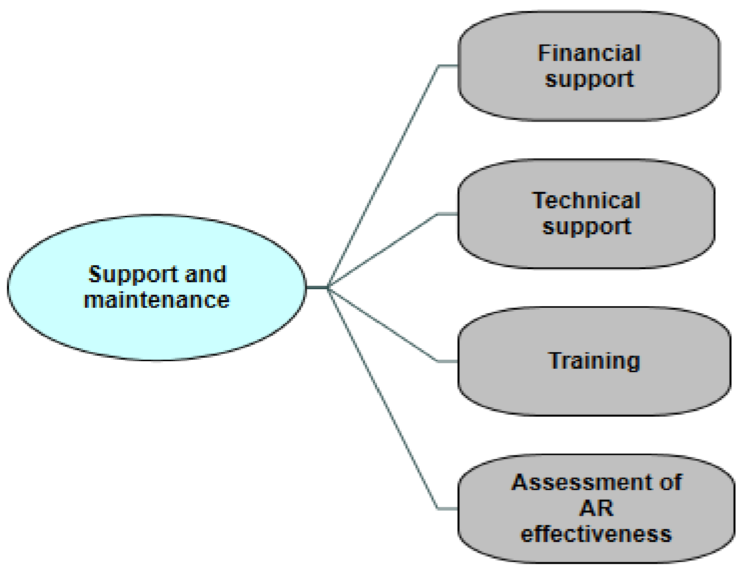


Figure 79. Concept map illustrating support and maintenance factors

The researcher noted from the interviews that all interviewees agreed on the potential for support and maintenance to affect the acceptance of AR in SA universities. It was believed that support and maintenance should be provided along the learning process as verified by the following:

- ***Financial support***

Firstly, financial support from the government to encourage the adoption of AR in SA universities was quoted by several interviewees. Nineteen of the interviewees mentioned financial support with the following comments:

> *"It will be hard to accept this innovative method in the beginning, and it will need massive support from the university by budgets and high-level workshops."* **(P8)**

> *"Based on my experience, budget and funding need to be considered …."* **(P9)**

> *"Budget and funding are the key factors to use AR in SA universities..."* **(P14)**

> *"It is essential the financial support from the government for the incorporation of Augmented Reality in Saudi universities"* **(P18)**

- ***Technical support***

In terms of AR technical support, the interviewees noted that providing necessary technical support and equipment such as hardware, software, and internet connectivity would facilitate the integration of AR and make lectures and students use the technology more. Moreover, interviewees mentioned ensuring that technical support is provided when students and faculty members need it. Sample quotes are shown below:

> *"AR is an ocean. The lecturers, for instance, cannot control everything. They need support from time to time from the*

specialist. Maintenance is important too. The provided contents might need to be changed or updated from time to time." **(P1)**

"Without a dedicated department for technical purposes, the whole experience will fail." **(P4)**

"1. Equipment of hardware such as computers, networks. 2. Training faculty members in using AR in teaching. 3. Adjusting the curriculum to fit AR. 4. Designing AR applications suitable for subjects. 5. Encouraging students to use AR as a culture." **(P10)**

"To make it successful, and to avoid bad conceptions about technology, support and maintenance should be provided along the learning process." **(P15)**

"It is important to have support staff to make sure users do not go through technical issues." **(P17)**

"Yes, with strong support, the success of integration will be higher. I worked at another college before where they used an online file-sharing system that they designed. It did not work so well because the response from the support team used to take weeks until we get an answer to any problem." **(P19)**

- ***Training***

The next commonly mentioned dimension of support and maintenance factor was the training to enable students and faculty members to use the AR technology effectively. All the interviewees in the study agreed that training was essential to be considered. Sample quotes are shown below:

"Providing proper training is the important factor that we should consider before incorporating AR into teaching and learning at SA universities." **(P7)**

"Training and teacher needs are the factors you should consider more appropriate than the ones which are specified in the above framework." **(P9)**

"Teachers are not digital natives, unlike students. So, they will need training before implementing any technology for learning." **(P15)**

- ***Assessment of AR effectiveness***

Concerning an ongoing evaluation and monitoring of AR effectiveness, all the interviewees in this study acknowledged that there is a need for ongoing technology assessment in plans to adopt AR in Saudi universities, as they claimed below:

"The evaluation plan is essential to evaluate the effectiveness of this technology and tell you whether or not AR in learning is being effective." **(P8)**

Formative and summative evaluations are very important to give feedback to the users of AR. This evaluation gives a chance to improve the use of AR." **(P9)**

"Continuous evaluation is required in order to improve the technology use and to determine students learning outcomes in an AR environment" **(P14)**

"Plus, research. Research should be conducted, and iterative evaluation of the technology should be carried out in order to

provide evidence-based data about the effectiveness of AR for learning." **(P15)**

In short, the support and maintenance factors were confirmed by all interviewees (please see Figure 80). All interviewees also acknowledged the role of the support and maintenance factor in facilitating the adoption of AR in the universities of SA. Consequently, this factor is incorporated in the Saudi universities' final AR framework.

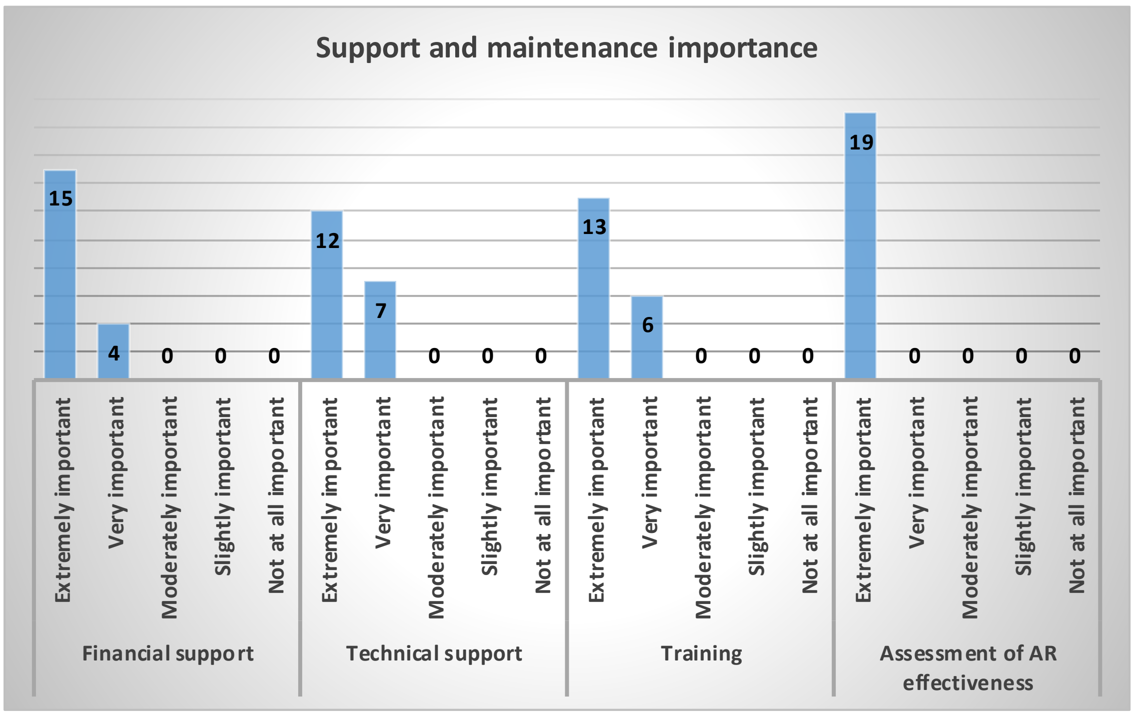


Figure 80: Interviewees agreement on the importance of each element of support and maintenance factors

5.6.3.8 Affective and Cognitive Factors

As explained in sections 2.9.10 and 2.9.11, affective and cognitive factors are related to the emotional and cognitive responses of an individual when using AR technology in the education process. The integration of AR technology in the educational process cannot be effective if human factors are not considered (Livingston, 2013). From the interview data analysis, understanding human experiences such as emotion and cognition in the AR educational environment was found to be a contributing factor to the future of AR integration and acceptance. Following an analysis of the interviewees' answers regarding affective and cognitive factors, two dimensions were identified. These are illustrated in Figure 81 and include cognitive flexibility and emotional response.

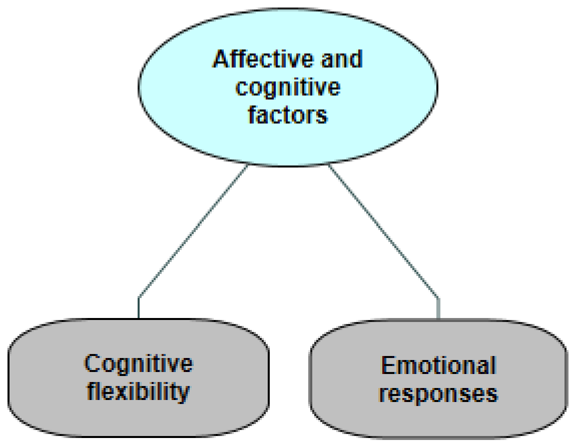


Figure 81. Concept map illustrating affective and cognitive factors

- ***Emotional responses***

Interviewees' opinions regarding this factor were highly supportive. Eighteen out of 19 (please see Figure 82) respondents declared that considering students' emotional responses (e.g. frustration, confusion, attraction, and enjoyment) to AR in the teaching and learning process is vital to encourage its acceptance by students as shown in the following comments:

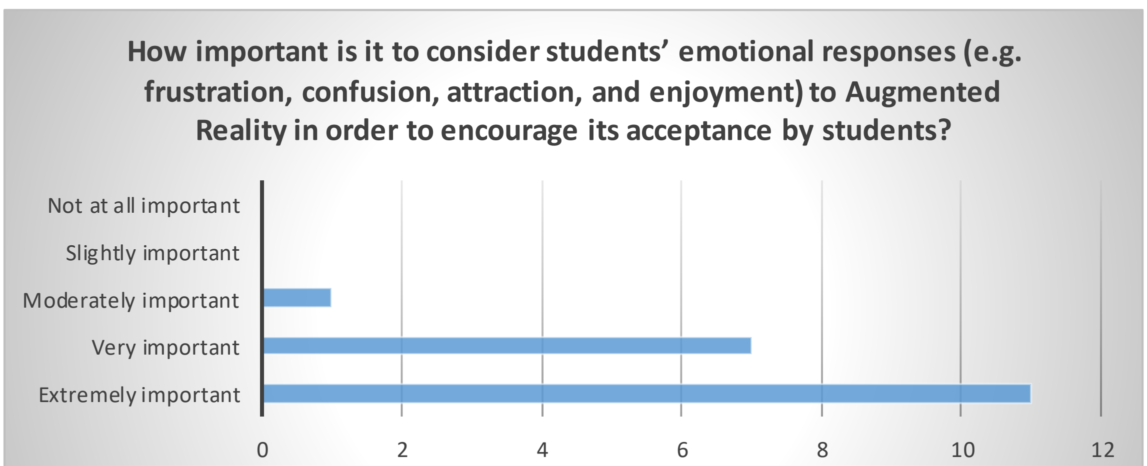
> *"The students' emotions towards using technology are one of the human factors that must be considered when integrating AR systems. We are expecting attraction and enjoyment of using such systems. If we do not feel that we find what we are looking for, then we would not use or accept the system."* **(P1)**

"Students' engagement is vital in using technology. They need encouragement as well as providing all necessary actions to have a positive reaction to using it." **(P6)**

"Human experience is important and will influence the use of the technology, either supported or not, by both students and teachers" **(P8)**

"Iterative evaluation of the potential of AR technology and students' responses and conceptions about it, make it very helpful to improve learning practices, and whether students benefited from it or otherwise." **(P13)**

"Yes, if learning with new technology will occur with frustration and confusion, then the student might have a negative reaction to the whole learning process. This might cause the student avoiding classes where these technologies are used, so it is essential to assess their emotional response." **(P19)**



	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Series1	11	7	1	0	0

Figure 82. Interviewees' agreement on the importance of the emotional factor.

- ***Cognitive flexibility***

Most of the interviewees (17 out of 19) support the importance of considering students' cognitive response (e.g. attention, memory, spatial skills, complexity) to AR in the teaching and learning process in order to encourage its acceptance by students. The following comments demonstrate interviewees' responses:

> *"Again, cognitive abilities are considered as an important human factor when using or modelling lots of interaction systems. Cognitive ability, for example, contributes to the individual's awareness ability of surroundings. One of the important cognitive abilities is cognitive flexibility. It is the ability of one to adapt to the new environment. Students in the new learning environment should adapt to this environment to be able to gain the target information. Thus, the designer should consider different individuals' cognitive abilities when modelling an augmented reality system."* **(P1)**

> *"In recent years, education has been concerned with the importance of the analysis stage in educational design. Therefore, it is necessary to take into account their age, cultural background and other characteristics while choosing the level of AR technology"* **(P3)**

> *"Using AR for the first time can have some negative effects on students' cognitive characteristics. Experts should have vital techniques to reduce these influences."* **(P9)**

> *"Cognitive response is one of the key factors to measure their acceptance to the technology."* **(P16)**

In brief, as shown in Figure 83, most interviewees agreed that considering the affective and cognitive factors will lead to encouraging both students and faculty members to use AR technology in higher education. Respondents confirmed that this factor would have a significant impact on the changes to be made in order to improve the user experience. This factor is included in Saudi universities' final AR framework.

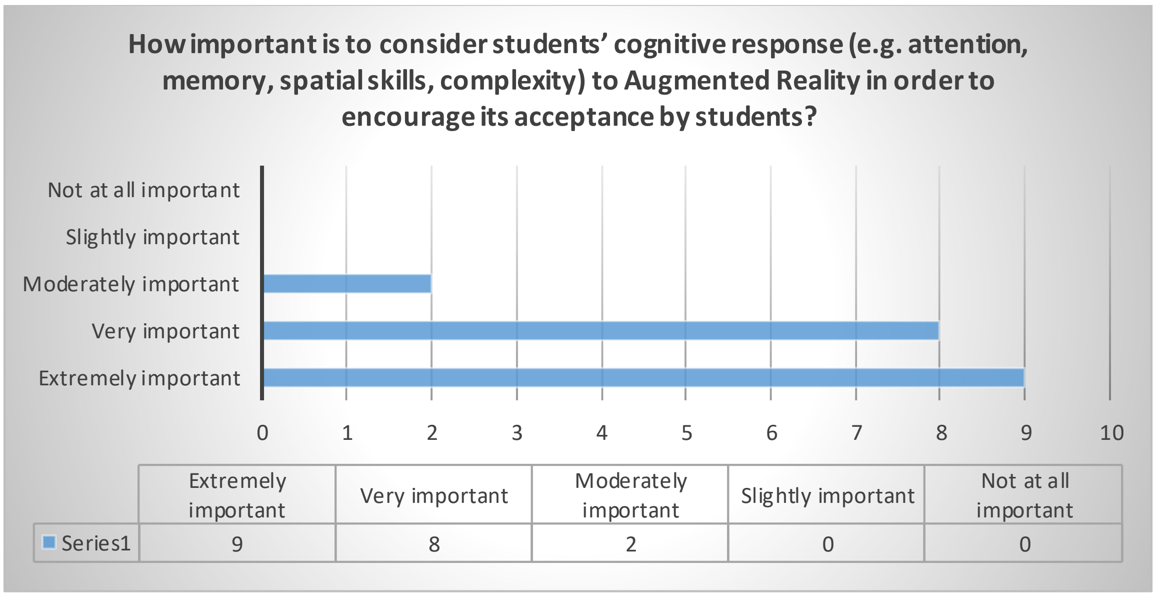


Figure 83. Interviewees' agreement on the importance of the cognitive factor

5.7 Appropriate Factors for AR Framework

The interviewees were also requested to determine which of the discussed factors they consider more appropriate than the ones which are identified in the proposed AR framework based on their experience. The following comments indicate their views:

> *"Cognitive flexibility might control some provided factors mentioned in the above figure."* **(P1)**

> *"I think that perceived usefulness is the most important factor because people might not fully adopt AR if they think that it is not useful."* **(P12)**

> *"Strong plan, training, teacher needs, budget and funding."* **(P8)**

> *"Support and maintenance: Because AR is not stable yet."* **(P10)**

> *"Pedagogical contribution."* **(P11)**

> *"Readiness, especially faculty and administrators."* **(P16)**

> *"Organisational environment; I have worked in two colleges where one was very open to incorporate new technologies, and the other one was very resistant and very traditional in their teaching and learning."* **(P19)**

It was noticeable that most of the interviewees consider support and maintenance (e.g. budget, cost, training), usability and design (e.g. suitability of the content), perceived usefulness and pedagogical contribution, readiness, and human factors (e.g. cognitive and emotional) as being the most relevant factors for the final AR framework of Saudi universities.

5.8 Assessment Questions and Modifications in the Framework

This section provides further justification and clarification for the inclusion of each factor in the final AR framework for SA universities. It presents an overview of respondents' answers to the enhanced AR framework and their comments. The researcher asked the interviewees questions about the AR framework for SA:

- If they chose to add new factors to the framework, what would they be? Why?
- If they had to remove any factors from the developed framework, what would they be? Why?

The answers to these questions show that 100% of the interviewees approved all the factors provided by the framework and suggested several changes to the final framework such as including one factor as mention in 5.6.3.4, related to appropriate pedagogical approaches and these changes were considered by the researcher and discussed in Table 62. The following comments indicate their opinions:

> *"I would like to add human factors to it, more importantly, the cognitive abilities. I think there is more need to include cognitive flexibility to the framework. Cognitive flexibility is important as AR is a new technology which can be adapted to help in improving the learning process."* **(P1)**

> *"I think it is important to focus on procedures, regulations, government policies, financial resources, and suitability of the content."* **(P3)**

> *"No, they are ok. Just pay more attention to cost and availability."* **(P4)**

> *"Government support. The budget of the AR will be provided by the government or the students themselves. To apply such technology needs a huge effort from different parties to get successful, and the communication could be one of the hardest things to apply in AR."* **(P8)**

> *"You might need to add another factor related to the teacher's competencies (ICT and pedagogically)."* **(P11)**

> *"Good but it needs some re-organisation to the stages. Usability could be added to the maintenance and support stage along with the design phase."* **(P16)**

Following examination of all comments and feedback, a decision was made to include a pedagogy factor. The other factors remained the same, with a few adjustments in some factors, such as removing the ethical concerns sub-factor, and including enjoyment in design and usability factors as described in sections 5.6.3.1 and 5.6.3.6. Table 62 summarises the interviewees' suggestions and the actions taken.

Table 62: Interviewees' suggestions and the actions are taken

Participant	Suggestions	Action	Reason
P1	Add cognitive flexibility to the AR framework.	**The suggested factor was not included.**	Cognitive flexibility is already discussed in the ***affective and cognitive factors,*** which has a logical place there according to all interviewees.
P3, P4 and P8	Pay more attention to government support and cost.	**These factors are already taken into consideration.**	These suggestions are already discussed in the ***support and maintenance factor***, which was supported by all interviewees as essential contributors to the AR framework.
P11	Add a factor related to ICT competencies.	**The suggested factor was not included.**	The suggested factor was discussed under the ***support and maintenance factor*** by offering training on the use and design of AR. This factor was agreed on by all interviewees.

P1, P3, P4, P6, P7, P8, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19	Add a pedagogy factor. Interviewees believed that pedagogical aspects are the foundation of any teaching and learning activities. So, they thought that when adopting a new learning method, such as AR technology, pedagogical principles and theories must be addressed to ensure this technology improves the learning outcomes.	**The pedagogy factor was added to the AR framework.**	In line with interviewees' comments and the literature review, ***pedagogy*** was added to the final framework.

Interviewees were asked to evaluate the overall set of factors for the integration of AR in Saudi universities. It was noticeable (see Figure 84), after analysing all 19 interviews, that the majority (12, or 63.16%) of the interviewees considered the proposed overall set of factors in AR framework for SA universities to be effective, while, (seven or 36.84%) evaluated it as moderately effective mentioning the need for weighting each factor and re-organising to the stages in the framework.

Thus, results from this phase were presented in response to the first research question from the educational AR experts' point of view and in response to the third research question.

- What are the factors that must be included in the AR framework for higher education in SA?
- What are the AR experts' perceptions towards the AR framework?

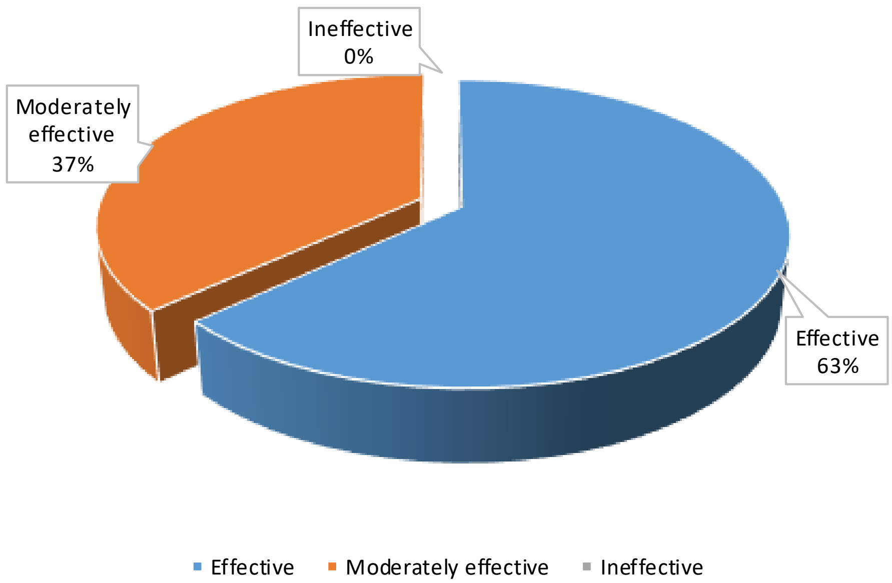


Figure 84: Interviewees' responses to the AR framework

In general, the researcher received positive responses from the interviewees, which encouraged him to continue this research. Positive comments are indicated in the following feedback:

> *"The addressed factors cover most of the needs for implementing an AR system in Saudi universities."* **(P1)**

> *"Covering these factors will lead to rich knowledge and outcomes of using this technology."* **(P5)**

> *"The framework covers all factors I can think of and all are essential."* **(P7)**

> *"These are the factors in any process of adopting new technology. From my point of view, it incorporated the most important factors."* **(P12)**

> *"It shows all the important factors that I can think of. Also, it clearly highlights many barrier factors and the failure to address them at an early stage can result in a failure of the whole integration process."* **(P19)**

5.9 Findings from the Interview Phase

An analysis of the interviews in this phase revealed a range of responses, all of which confirmed the importance of the factors that make up the final framework. Interviewees indicate their confirmation and their level of agreement with the importance of each factor.

The interviewed experts concentrated on awareness of the pedagogical value and usefulness of AR technology before any effort to integrate the AR educational initiative into the Saudi university environment. It was also common to include pedagogy as a critical factor to the framework. Interviewees also strongly recommended the adoption of AR technologies, to improve education among different classes of students, to be aligned with existing pedagogical approaches, such as experiential education in AR environments. Some participants cautioned that AR as a learning tool could only become a waste of time and resources if the learning process in AR environments does not utilise new and current theories and practices by Saudi lecturers.

Furthermore, the usability factors were reported by most of the interviewees. They mentioned that the familiarity of the students and faculty members with such technology plays a vital role in making their learning a success. Also, interviewees highlighted the need to provide the faculty staff with strong support and maintenance during their implementation process and to design and develop AR-friendly learning content. In general, interviewees stressed the need for providing extensive training to teachers and students involved in AR educational environments and continuous evaluations to enhance the learning content and learning outcomes of AR tools.

Several interviewees pointed out that some of the cultural issues include religious and the content presented by AR technology. Nevertheless, despite all the challenges, the interviewees stressed that SA can control social and institutional culture issues as any other regular technology and that SA undergoes enormous digital transformation.

Interviewees' responses were evaluated to determine the weighting and order of these factors based on their influences by using a five-point scale: from 1=Unimportant to 5=Important. As it can be seen in Figure 85 below, the perceived pedagogical contribution factor was the highest factor with 92 of the scoring values, followed by the perceived usefulness factor with 91 scoring value. The need for usability and design to integrate AR in SA universities occupied the third-highest scoring value of 90 respondents suggesting that AR needs to be acceptable, easy to use and enjoyable. This is followed by the pedagogy factor, which was seen as a critical factor with 88.5 in the classification of interviewees emphasising the need to apply AR technology based on best pedagogical practices and theories.

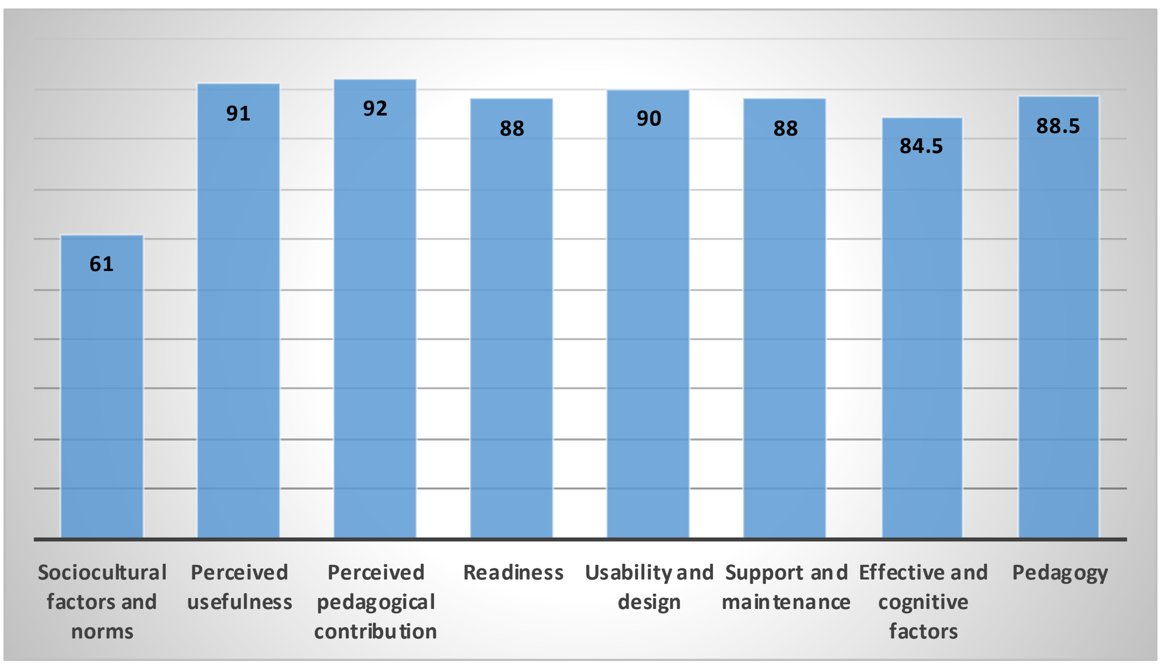


Figure 85. Rating overall factors

The factors of technology readiness, willingness, and support and maintenance were rated with the same scoring value of 88 as crucial factors via raising the awareness, providing financial and technical support, well-built infrastructure, providing specialised training for students and lecturers, and ongoing evaluation of AR effectiveness. Regarding the human factors and characteristics, emotional and cognitive factors were also seen as a crucially important factor with 84.5 scoring value from respondents supporting the need for considering emotional and cognitive aspect during AR implementation. In contrast, the sociocultural and norms factors received a relatively lower score of 61. Respondents gave several reasons regarding this factor (see section 5.6.3.1). However, the researcher kept this factor in the framework because more than half of the interviewees agreed that the sociocultural factor and norms play a pivotal role in the implementation of AR in SA higher education.

Based on the interview findings and analysis, all the suggested factors from the quantitative phase (survey) (please see Table 55) were confirmed by the interviewees. The outcomes of the data collection and analysis conducted during this study reveal a few changes to the initial and second AR framework. These changes are: (1) an additional factor was confirmed, 'Pedagogy', with two associated sub-factors after further examination by most (94.74%) of the educational technology experts and this factor was added to the final AR framework. It was seen as a vitally important factor to be added to the list of factors in the framework, encouraging the need for pedagogical theories and practices to be the foundation of any teaching and learning activities. (2) As identified in the thematic interview analysis, the enjoyable experience was included under design and usability theme and thus depicted in the framework. (3) Ethical concerns were not found to be an essential item based on the interview results and therefore, was removed.

The concept map in Figure 86 below illustrates all critical factors and sub-factors for incorporating AR in SA universities. Figure 87 depicts the final framework after embedment.

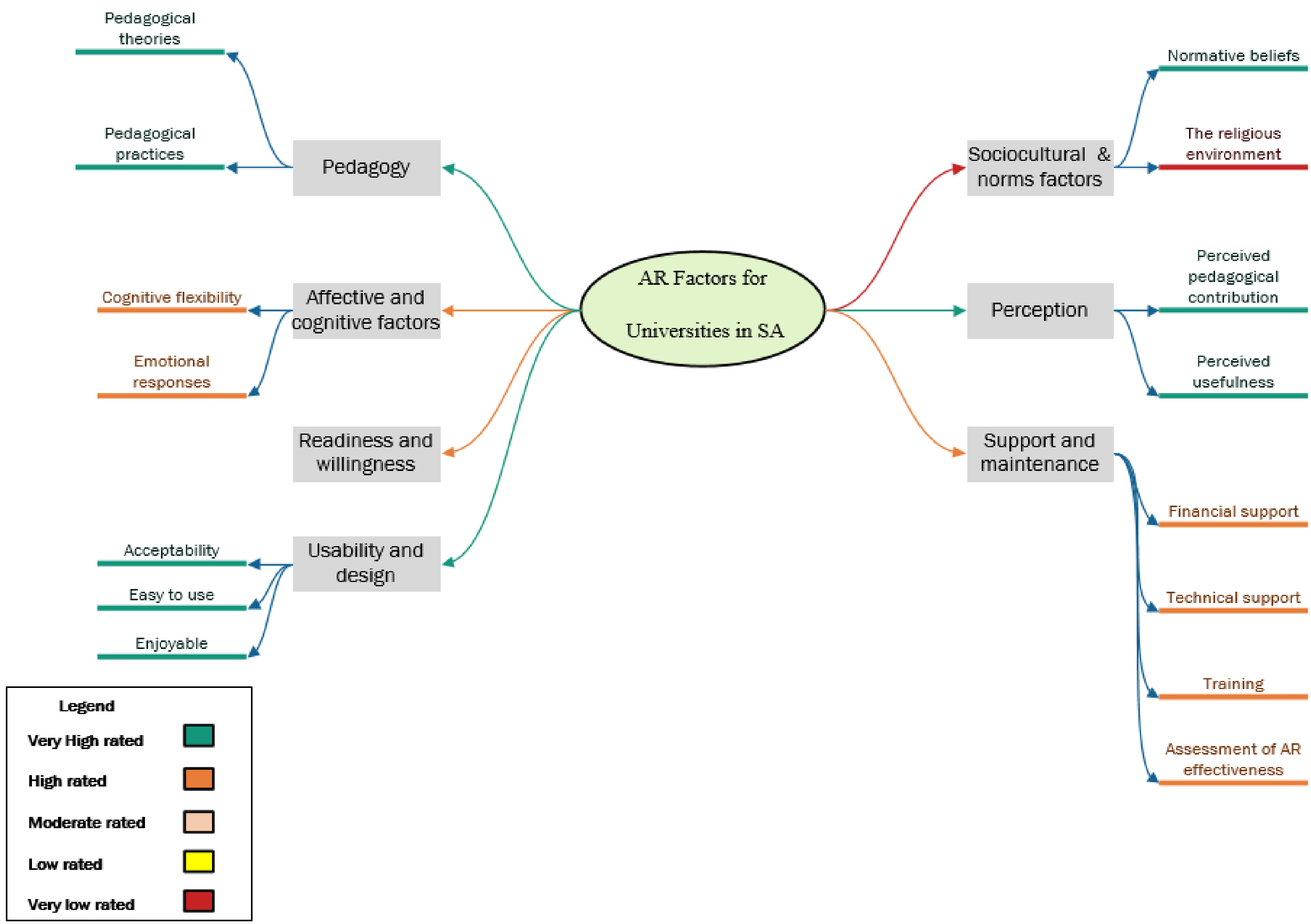


Figure 86. Conceptual map of overall factors from the interview phase

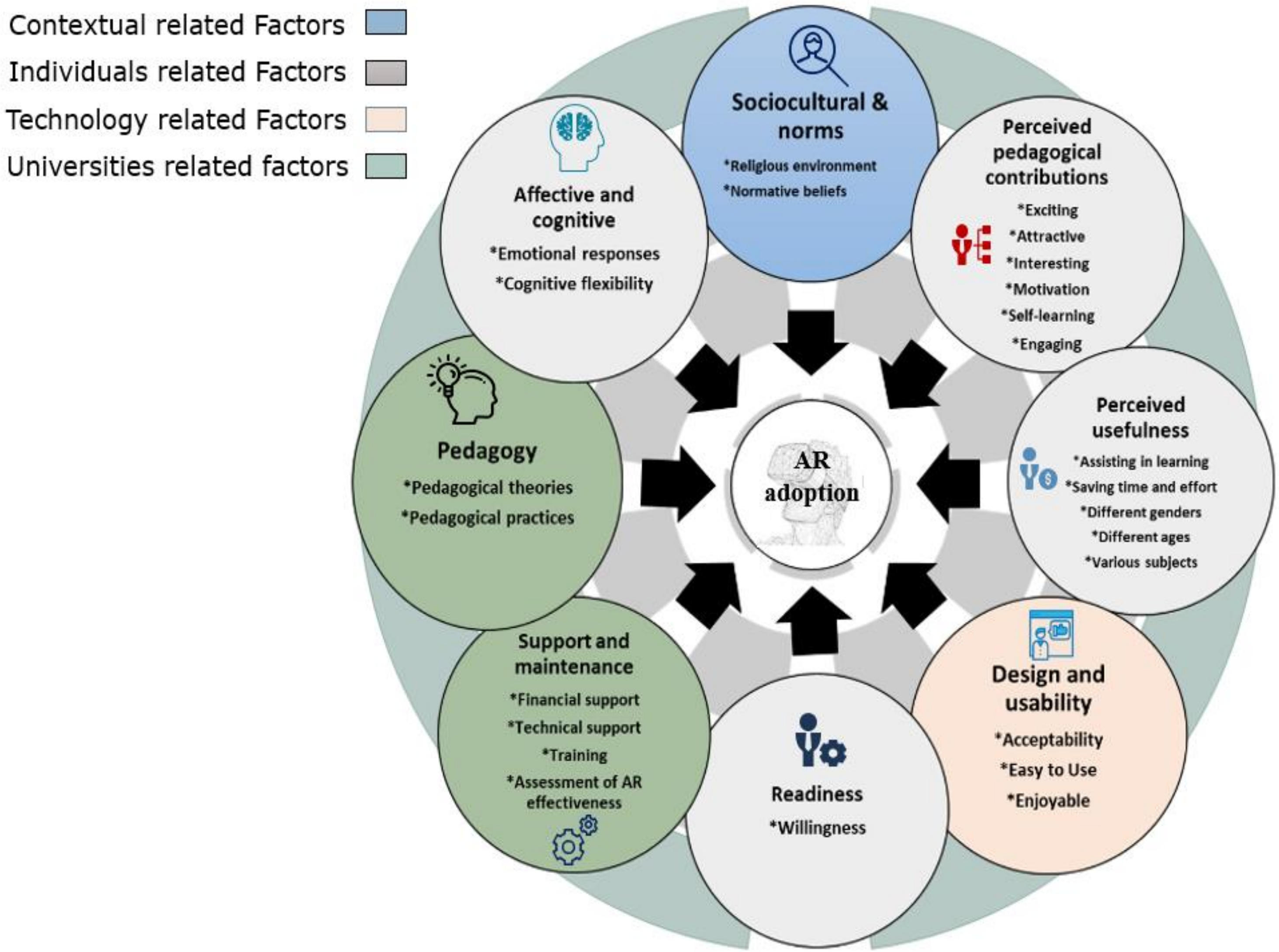


Figure 87. AR Framework for Universities in SA (Final Version)

5.10 Conclusion

This chapter discusses the interviews conducted among experts of AR in higher education in SA to confirm the answer to the first and third research questions by refining the second draft AR framework resulting from the survey responses. Firstly, the interview design and rationale were described. The target population was then justified, as well as the demographic information of the respondents was illustrated. It was found that all selected interviewees were competent with AR technology, especially in the education context and have worked in SA. The interview data analysis techniques were discussed. These include the deductive thematic analysis of the interview data as well as the categories and themes used to establish a comprehensive approach of crucial results. The rest of the chapter provided the results of the interview data analysis for each identified factor.

The qualitative method aimed to assess the draft AR framework, presented in section 3.3.5.6, and to confirm the factors identified by the factor analysis in the quantitative method. Moreover, it outlined several changes made to the initial framework due to improving the AR experts' opinions. As a result of the interviews, the interviewees confirmed all the suggested factors from the previous phase and approved, adding only one further factor. The final AR framework consolidates all these factors which were selected after careful validation.

The findings from this phase were used to refine the final AR framework, which shows a comprehensive set of factors that inspire and influence the integration of AR technology in higher education. The research finding and the final AR framework is discussed in detail in the next chapter.

Chapter 6. Research Findings and Conclusion

6.1 Introduction

The previous chapter showed the final phase of the research and consolidation of factors in the framework that was endorsed and validated by interviews. The final framework was yielded from the interview data, which enhanced the overall set of factors for the introduction of AR technologies into universities in SA. The final AR Framework for SAn Universities (ARFSAU) established from the combination of all the factors derived from the literature review, surveys, and interviews. It is envisioned that the final ARFSAU framework resulting from this research will play an essential role in guiding universities in SA for AR incorporation.

This research has been divided into six chapters. Chapter one presented the subject of the study with definitions, the setting of the research, the problem, objectives and questions. Chapter 2 reviewed the related literature. Then, the methodology chapter (Chapter 3) clarified the research design, measurements, and sampling and data collection procedures. In chapter 4, the quantitative data assessment, the findings and the improved AR framework were described in detail. Chapter 5 outlined the data analysis of the interviews, and the final AR framework resulted from both phases. This chapter (Chapter 6) includes a summary of the study's objectives, discusses the main findings and answers the research questions. It then provides recommendations and presents the study's limitations and potential areas for future research.

6.2 Summary of Research

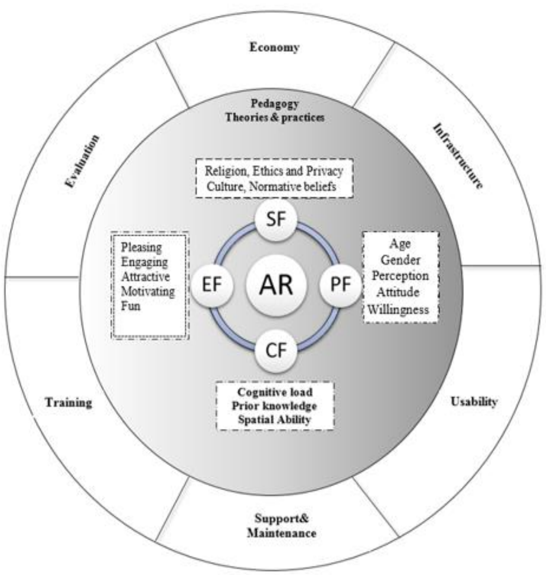
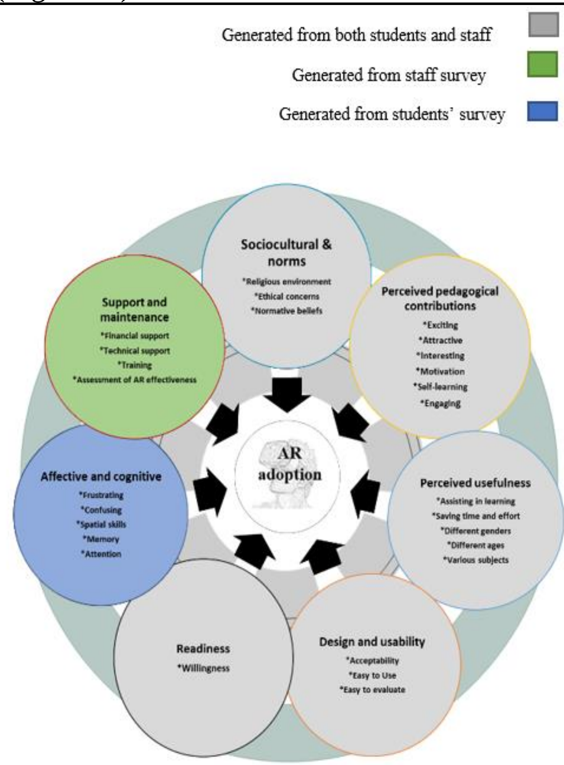
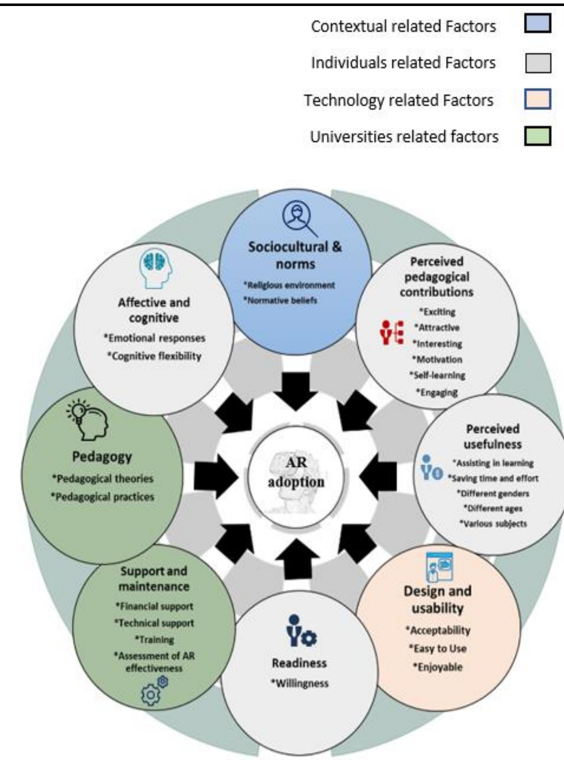
To summarise the research and to answer the research questions, the literature was extensively reviewed, and critical global factors were created. Most studies on the introduction and adoption of educational AR identify AR adoption factors and challenges. This study also offers insight into the factors and challenges of AR technology in education and suggests steps developing countries should take to prepare for AR implementation and adoption. These assisted in building a conceptual framework of factors that could promote the effective implementation of an AR technology environment in SA universities, as none of the previous models and frameworks had done so. The initial AR framework was developed to combine all factors identified from previous AR studies and published articles related to AR technology adoption in higher education.

Then, an explanatory, sequential mixed-method design comprising two phases of data collection was applied to address the key research questions and enrich the findings of this study. The preliminary framework was then examined by stakeholders using a web-based survey of 729 (501 students, 228 academic and e-learning staff) participants. The objective of the quantitative phase was to examine students, lecturers, e-learning staff's perceptions of the integration of AR in Saudi universities and to assess the factors identified in the literature. In order to generate a new set of robust factors, EFA via SPSS was used to analyse web-based survey data to define groups of interrelated factors. The factor analysis provided a new, distinct list of factors that was more coherent than the initial grouping in its interpretation of the data. An improved AR framework was formed as a consequence of this phase. The web-based survey results analysis was presented in Chapter 4.

The improved AR framework was derived from factor analysis and qualitatively assessed via online SSI with 19 interviewees. The qualitative phase was conducted to support/supplement the quantitative result from the educational AR experts' opinions and to answer the third research question. The collected data were analysed using the thematic analysis technique recommended by Braun and Clarke (2006). The data analysis verified that all-important factors were included in the improved AR framework. Results from this study enhanced the overall set of important factors that must be included in the ARFSAU to adopt this technology successfully. The interview analysis results were presented in Chapter 5. Finally, several actionable recommendations for the integration of the AR environment into the higher education system in SA were suggested. Table 63 summarises the framework evolution in all three stages.

The proposed ARFSAU framework for SA universities could be implemented in other developing countries by dropping some of these factors or adding other factors based on these countries' context. For instance, Saudi, as mention in 1.8, has firm Islamic root, and the education system was shaped based on the Islamic rules. Adopting new technologies must be aligned with the sociocultural of Saudi Arabia. Thus, the sociocultural factor and norms were included in the final framework for Saudi Arabia context and could be omitted to make the ARFSAU framework applicable in other developing countries.

Table 63: Changes and development of the ARFSAU

Version 1	Version 2	Version 3 (Final Version)
Initial AR Framework generated from the literature review phase) (Figure 28)	Refined AR Framework (generated after evaluating the initial framework through the online survey phase by students, faculty members, and e-learning departments' staff) (Figure 66)	Final Version of the AR Framework (ARFSAU) generated from the interviews phase with AR experts (Figure 87)
		

6.3 Research Findings Overview

This thesis examined and assessed perceptions regarding the adoption of AR technology in SA's higher education sector, through the development of a new framework of AR. It can be clearly stated that AR is an excellent tool but needs to be assessed in terms of the factors which might support or hinder its adoption. Providing a framework to guide its implementation in the education system is also required. An examination of academic staff, students, and AR technology experts were conducted in the universities of SA to provide an understanding of this issue. Table 64 illustrates the relationships between the research questions, objectives; method and analysis. The research questions were:

Q1 What are the factors that must be included in an AR framework for universities in SA?

Q2 What are the perceptions of students, faculty members, and e-learning departments towards integrating AR as a teaching and learning tool compared with the traditional method?

Q3 What are the AR experts' perceptions towards the AR framework?

Table 64: The relationships between the research questions, objectives, method and analysis

Research Question	Research Objective	Research Method	Analysis
Q1 What are the factors that must be included in the AR framework for higher education in SA?	To ascertain the factors that must be included in the AR framework for higher education in SA	• Literature Review • Mixed-methods	• Content analysis • EFA on quantitative data from Survey • Thematic analysis of qualitative data from the interview

Research Question	Research Objective	Research Method	Analysis
Q2 What are the perceptions of students, faculty members, and e-learning departments towards integrating AR as a teaching and learning tool compared with the traditional methods?	To determine students, faculty members, and e-learning departments' perceptions towards AR as a teaching and learning tool compared with the traditional methods.	• Quantitative method (online survey) investigates students', lecturers', and e-learning staff's perception	• EFA
Q3 What are the AR experts' perceptions towards the augmented reality framework?	To assess the AR experts' perceptions towards the augmented reality framework.	• Qualitative method (SS interview) explores the AR experts' perceptions	• Thematic analysis of qualitative data from the interview

Table 65 shows in which phase the research questions were answered.

Table 65: An indication in which phase the research questions were answered.

Questions / Phases	Q1	Q2	Q3
Literature review	✓	X	X
Online survey	✓	✓	X
SS interview	✓	X	✓

6.3.1 Research Question One

Following data collection and analysis described in Chapters 2, 4, 5, the literature review, survey, and interview revealed the most common factors that influence AR adoption in Saudi universities, and these were compiled to produce the final AR framework shown in Figure 87. The first research question was intended to classify the factors for developing an AR framework and environment for universities in SA. Thus, the literature review, the survey of students, faculty members, e-learning departments, and interviews of AR experts, identified the most common factors for the final AR framework.

This study has shown that there are eight factors found contributing to successful incorporating of the educational environment of AR: sociocultural and norms, perceived pedagogical contribution, perceived usefulness, pedagogy, readiness and willingness, usability and design, support and maintenance, and affective and cognitive factors. Each factor in the ARFSAU will be discussed in the following subsections.

6.3.1.1 Contextual-Related Factors

This section reports on how contextual factors are essential for the adoption of AR and need to be included in the final ARFSAU. Two contextual-related factors (sociocultural and norms factors) were found to have a substantial impact. These two factors are discussed next.

6.3.1.1.1 Sociocultural Factor

As mentioned previously (see section 1.8), the education system in SA is guided by the government's policies, which are derived from the Islamic culture and based on regulations. The role of sociocultural factors in technology integration was a frequently discussed influential factor, especially concerning cultural and religious issues (Erumban & Jong, 2006; Jung & Lee, 2020; Tan et al., 2009). It can be described in this study as the perception of potential cultural and religious issues. The literature review (Nistor et al., 2011; Paul & Steve, 1998) indicated that cultural settings could affect how technologies are adopted.

From the student, academic, and e-learning staff surveys, and interview experts, the results showed that incorporating AR in SA universities should be aligned with Islamic environments and laws. In other words, to integrate or design a new technology to be developed in the higher education system in SA, religious regulations need to be followed and considered. However, according to the interview findings, there were mixed views on whether the sociocultural factor was considered a critical factor in integrating AR technology. Some participants emphasised that the new generations and culture of SA are fertile for applying new technologies and attract every innovation at the level of education or others. In fact, with the unveiling of the ambitious Vision 2030 that aims to develop SA and bring it in line with other countries, it can be said that politically, SA is in a unique position to take advantage of modernisation and current technologies. However, the quantitative results indicate that it is an essential factor, and therefore, should be considered to some extent during the integration of AR technologies. These results are similar to those observed in earlier studies (Hofstede, 1984; Tarhini et al., 2015; Young, 2008) indicating that cultural settings significantly influence the design and incorporation of new technology.

6.3.1.1.2 Norm Factors

In addition to the sociocultural factors, the literature suggests that exertion of normative pressure from current users to others can potentially lead to widespread consumption and mass adoption of new technology (Ajjan & Hartshorne, 2008; Ertmer et al., 2012; Jung & Lee, 2020; Yeap et al., 2016). Another important finding was the personal normative beliefs in this study. Normative beliefs are those that compel an individual to consider the opinion of people who are important to him/her, such as colleagues, work managers, other students, and relatives when contemplating the use of AR technology in learning and teaching.

In this study, students' and academic staff's decisions to use technologies in their teaching and learning were found to be influenced by others within their universities and communities. Lecturers' and academic staff's decisions regarding the use of AR in their teaching appeared to be inspired by their department heads and deans. It can be that the influence of deans and lecturers to their partners will minimise lecturers' decision-making uncertainty due to risks in implementing AR, such as being time-consuming or budget blowouts. Thus, the decision regarding the use of AR is based on the beliefs and choices of the heads of department. Encouragement of a superior can be used as an excuse to take the risk. Furthermore, students are more likely to integrate and use AR technologies when this is supported and encouraged by their teachers and friends.

The findings of this study are consistent with those of Al-Somali et al. (2009), Huiying et al. (2010) and Raza et al. (2018) who found that societies shape individuals' perceptions towards the adoption of new technologies. This finding corroborates the ideas of Ajzen and Fishbein (1980) who proposed that staff might integrate a new technology not because of its effectiveness but because of perceived social pressure on them to engage or not engage. The findings from this study indicated that faculty members should promote the technologies and teaching methods that they believe in—regardless of their causes—and these trends will influence the lesser experienced students. Although their impact is temporary, it may extend to their field by creating approaches to their peers by offering workshops in their universities.

6.3.1.2 Individual-Related Factors

This section discusses the findings concerning individual-related factors such as perception, readiness, affective and cognitive factors and how these factors influence the integration of AR.

6.3.1.2.1 Perceived Pedagogical Contributions

The literature review identified potential critical success factors related to personal perception (see section 2.9.2). This includes perceiving both the pedagogical benefits and limitations of educational technologies and its relevance to pedagogical designs and plans. As Topper (2005, p. 304) argues "for teachers to use technology in support of their teaching, and to see it as a pedagogically useful tool, they must be confident and competent with the technology they are planning to use." Findings from previous studies (Ertmer, 2005; Lim & Chan, 2007; Liu, 2011) indicated that lecturers' pedagogical beliefs and perceptions need to be considered to integrate technology fully. A quantitative study was conducted by Bower et al. (2016) investigating the insights of higher education experts regarding applicable technologies like AR in learning and teaching. Lack of perceived pedagogical benefit was found to be one of the obstacles to the adoption of AR for learning and teaching in higher education. According to Taimalu and Luik (2019), pedagogical knowledge of educational technologies significantly impacts on technology integration. Ertmer and Ottenbreit-Leftwich (2010) found that four key factors, namely: pedagogical beliefs, teacher knowledge, self-efficacy, and subject and school culture, are influential factors that impact on technology integration and use. Tondeur et al. (2018) concluded that teacher-perceived pedagogical values could be substantial barriers to the use of technology in their teaching.

The first and second question in this study sought to determine perceptions and the factors that will help to integrate AR in the higher education sector in AS. The perceived pedagogical contribution of AR technology was identified as an essential perception and factor to integrate AR in SA universities and to be included in an AR framework for SA. This is because higher education in SA needs significant changes in pedagogy to be in line with the global standards. This technology can have a considerable contribution in this regard. The survey and interview findings revealed that faculty members and students who perceive AR pedagogical contributions are more likely to integrate and use this technology. Participants in this study believe that employing AR in education helps to deliver the information in less time. In addition, the results showed that the AR tool in higher education has other benefits because it is exciting, enjoyable and motivating, and it promotes both independent and cooperative learning. As was expressed in interview responses, promoting the AR pedagogical ability is vital to consider because when technologies like AR are perceived to have pedagogical benefits by both students and faculty members, it goes a long way in encouraging students and faculty members alike to incorporate and use AR technology.

These findings align with Dalim et al. (2017) study of factors influencing the acceptance of AR in education, which concludes that participants have positive attitudes towards AR in education because of its pedagogical contribution. The importance of the unique pedagogical ability of AR (Lee et al., 2010) could encourage the adoption of AR in education. Furthermore, this study finding is in agreement with the findings of Tondeur et al. (2017), which showed that pedagogical beliefs regarding new technologies might prevent their integration in education.

6.3.1.2.2 Perceived Usefulness

Prior studies have noted the importance of perceived usefulness and its value in integrating technology like TAM (Davis, 1989) and the Diffusion of Innovations Model (Rogers,1983), as well as in various contexts with extensions of these models (see sections 2.8 and 2.9.2). Users are likely to have a positive attitude towards technology when it is perceived as useful, which affects their intention to use the technology and how it is used. Notably, perceived usefulness is mentioned in some studies as a significant factor in students' learning using AR technology (Cheng, 2017; Wojciechowski & Cellary, 2013). Although AR has taken giant steps in the field of raising the level of learning and innovation, there is an obstacle which only a few people are exposed to, the usefulness of AR in the field of education (Wang, 2012). Perceived AR usefulness was found to encourage the adoption of AR as a teaching and learning method.

The second question in this research was "What are the students, lecturers, and e-learning departments' perceptions towards AR as a teaching tool compared with the traditional methods?" This involved analysing the perceptions of students, academic staff, and e-learning staff to determine participants' views and opinions about AR technology in education in the quantitative phase. Interestingly, the perceptions of students, academic, and e-learning staff were generally positive because they considered that AR technology would be useful in higher education (see Section 4.7). In particular, they believed that AR is useful for different disciplines as it saved time and effort for the teachers and students, allowing them to accomplish things that they could not easily do with the traditional learning methods; it was a supplementary tool for learning and teaching, and it was suitable for different genders and ages. Moreover, analysing the perceptions of AR experts in education in the interview phase also revealed perceived AR usefulness would depend on how much this technology will be embedded in the curriculum, so lecturers and students will feel the importance of this technology to explain concepts and this will lead to more understanding.

Overall, this research emphasises the importance of considering the perceived usefulness factor before the implementation of AR technology in higher education. The results of this study are consistent with those of other studies and suggest that students demonstrate a positive attitude when they perceive the usefulness of new technology. For instance, Chang et al. (2011) stated that the AR perceived usefulness indicator influences the intention to integrate AR in teaching and learning. Perceived usefulness is recommended in literature to promote the adoption of AR in education (e.g., Chang, Chen, Huang & Huang, 2011; Tsai, Tsai & Hwang, 2010). The perception of the usefulness of AR technology in education was incorporated into the framework, and its importance was affirmed by the data collection methods, including the surveys and interviews with AR experts and educational technology staff.

6.3.1.2.3 Readiness or Willingness

The literature emphasises that initiating an AR system in universities requires technology readiness and personal willingness to establish a coherent and possible strategy (Mosa et al., 2016). Readiness is a critical factor in deciding whether a technology would be successfully implemented or not. Mahat et al. (2012) argue that faculty members and students require the propensity to embrace and use AR technology as a teaching and learning method. Several studies (Gess-Newsome et al., 2003; Ghaith & Yaghi, 1997; Groff & Mouza, 2008; Padmanathan & Lachmy Narayana, 2018) have found that the willingness to integrate and adopt innovations into learning practice is essential for successful innovation.

Readiness and willingness were found in the current study to be crucial for the successful employment of AR technology. A primary finding of this study is that faculty members and e-learning staff in SA universities already had the readiness to use AR technology as a teaching tool. They reported their willingness to use AR for activities concerning the teaching of course materials or are already using it. Also, students exhibit a higher propensity to embrace and use AR in their university studies and are willing to learn more about AR technology. Interestingly, this study found that participants who believed in the capabilities of AR in enhancing higher education learning outcomes expressed the willingness to use AR technology in the future for teaching and professional activities. Hence, the readiness and willingness have been confirmed as being of critical importance by the results of the data collection phases.

Alkhattabi (2017) argued that willingness is an affective factor influencing the acceptance of AR as an e-learning tool. In line with this argument, the findings of the interviews indicate that readiness and willingness are also critical to encouraging AR adoption and use. This implies that higher education in SA needs to ensure AR readiness via raising awareness and providing resources and workshops. This finding is supported by prior studies (Christensen & Knezek, 2014; Koszalka et al., 2014) which have noted the importance of readiness to integrate technologies in education as an integral component of learning and is required for successful reform.

6.3.1.2.4 Affective and cognitive factors

Findings from previous studies (Kim & Malhotra, 2005; Venkatesh et al., 2003) showed that specific emotions such as enjoyment and pleasure were found to influence users' attitudes towards, and later use of, the new technology. Also, the case highlights that motivation and enjoyment are found to be increased by using AR applications in the learning environment, which resulted in a positive attitude (Mahadzir & Phung, 2013; Vate-U-Lan, 2012). The most discussed aspects of AR implementation in education were considered by the researcher in this study to make AR technology to be accepted entirely.

The results of this study suggested that understanding the emotional experience related to using AR technologies in education was indeed necessary to take into account and include in the AR framework. A negative emotional experience might decrease the student's readiness and attitude towards using AR technology and could ensure the rejection of the technology. This study found that participants believed that using AR technology in their learning is a pleasing and attractive experience and will result in cognitive load reduction. Interview participants also pointed out that, as AR is applied in the educational environment, taking care of students' experience and individual differences between students such as cognitive and emotional reactions will contribute to their acceptance and use of these technologies. Further, it was found in the current research that failure to provide positive emotional experiences and the cognitive load reduction in an AR learning environment will limit the use of AR technology. For example, participant number 19 (P19) stated that if a student experienced negative emotions (frustration, lack of understanding) when using AR tools, "this might cause the student to avoid classes where these technologies are used, so it is essential to assess their emotional response". Both cognitive and affective factors were supported by all interview participants as an influencing factor in adopting AR as a learning method.

This finding is in agreement with a Moorhouse and Jung (2017) study, which showed the emotional response to AR technology determines the future of its integration and acceptance. Consistent with the present results, previous studies have demonstrated that there is a strong relationship between cognitive load and students' attitudes towards AR in the educational context. For instance, Küçük et al. (2014) indicated that more positive attitudes were exhibited by students who perceived a lower cognitive load when using AR. A study conducted by Cheng (2017) also explored the role of perceived cognitive load in students' attitude towards an AR book. As a result, the students' perceived mental load had relatively high negative correlations with their attitudes. According to Ibáñez & Delgado-Kloos (2018), increasing cognitive load and promoting distraction for students were found as the disadvantages associated with AR technology in education.

6.3.1.3 University-Related Factors

The results showed significant factors related to universities (support and maintenance, and pedagogy). Support and maintenance from various quarters, like the universities and the government, were identified as factors that affected the incorporation of AR. The support included government financial, technical and administrative support. Similarly, the pedagogy factor was identified as a critical enabler to the integration of AR in the current study. These two factors are discussed next.

6.3.1.3.1 Support and Maintenance

Within the survey findings, the adoption of AR by faculty members and e-learning staff could be influenced by different kinds of support including government support, administrative support (e.g. training and assessment), and technical support from the universities (see section 4.7.2.6). Several factors were identified from the literature (Masood & Egger, 2019; Mumtaz, 2000), which influences technology adoption decisions in organizations, such as the quality of software and hardware, support, training and attitudes of policymakers.

The relevant literature recommends a wide range of financial and government support to foster technology integration in an educational context (Bonsu et al., 2013; Buabeng-Andoh, 2012). The financial sub-factor was found in this study as one of the most significant kinds of support that the participants believed would lead to the effective use of any technology in higher education. In the current study, it was found that funding and an adequate budget are essential to the success of AR integration in SA higher education. Poor financial support was found to be a potential barrier to technology adoption in an Oh and Park (2009) study who surveyed 133 faculty members in Korea. In a similar vein, the interviewees repeatedly pointed out that adequate financial resources are needed to provide AR technology with enough equipment like hardware, software, connectivity and other information and communication devices. The cost of these requirements needs to be estimated by the Saudi higher education sector, and they should be aware that securing one-time funding for this type of technology must be adequate. They need to understand the importance of maintaining an up-to-date AR technology infrastructure. This finding is consistent with those of Beggs (2000) who conducted a survey examining 348 U.S. instructors regarding the extent to which certain factors would hinder or facilitate technology adoption. They reported that equipment availability is one of the most exceptional facilitators of technology integration in their faculty.

Similarly, Miller and Dousay (2015, p. 9) concluded that "challenges, when they arise, are usually related to varying levels of access to the hardware and software needed to implement AR, though these challenges are waning." Furthermore, technical support was reported by both academic and e-learning staff in this study as vital to the implementation of AR in universities. The relevant literature suggests that available technical support is essential to delivering a learning AR technology service that meets users' needs (Muir et al., 2004). The results from both the surveys and interviews confirmed technical support as one of the crucial sub-factors that can limit the use of AR (see section 5.6.3.7). This finding was supported by Wójcik (2015), who suggested that AR can enrich the learning experience and be used anytime when university authorities provide technical considerations (hardware, software). These results were also matched by the findings of other studies (Alkhattabi 2017; Di Serio et al. 2013).

Furthermore, the literature suggests regular training to increase and encourage the use of AR by faculty members and students (Wang 2012). Lacey et al. (2014) stated that training and support were critical to getting teachers comfortable with instructional tools. Teachers must understand new educational tools and how to implement them within their curriculum to provide quality learning. Participants in the current study highlighted the importance of training faculty members and students before integrating this technology in higher education. Consistent with the results of this study, Chin et al. (2016, p. 365) stated that "If teachers want to be able to independently customise an AR system, specialised training and continuing education courses must be provided by computer professionals. [Without] the above reasons, likely, AR systems cannot be strongly promoted or applied to a variety of educational endeavours." The interviews further indicate that securing sufficient and ongoing training sessions and workshops for students and instructors to use innovative technologies such as AR will contribute to the growth and development of this technology for teaching and learning. Incorporating AR into teaching requires adequate staff skills and confidence and these can be acquired through proper training.

Thus, providing training in using AR technology promotes user's awareness of the usefulness of the technology and whether it is easy to use, which leverages their attitude towards it, and hence increases the likelihood they will integrate it. This is supported by Alkhattabi (2017), who found that respondents indicated that the lack of teachers' IT skills was a general barrier to the adoption of AR. Ibáñez and Delgado-Kloos (2018) claim that using AR in learning activities requires students to be trained before the expected use. Furthermore, training should be extended to include lecturers to increase the use of this technology in current education.

In this study, evaluating and monitoring the impact and use of AR in the learning and teaching process was found to be essential if there is to be widespread uptake of this technology in Saudi universities. Evaluation is related to a continuous assessment of the technology's progress and effectiveness within a system, including assessment of the technology itself and those who use the technology. A thorough evaluation would help to determine whether the adopted technology is achieving its objectives and ensure that it is still on track to do so (Intel, 2013). An appropriate evaluation was encouraged in previous studies as a key to successful technology integration in SAn higher education (Charoula & Nicos, 2006; Eteokleous, 2008; Porter et al., 2014; Taylor & Newton, 2013). Currently, "the AR learning environments reviewed reveal that there is a maturity in the use of AR to support constructivist or collaborative instructional strategies; what is missing is the provision of evaluations of the impact of AR technology on the acquisition of scientific inquiry or collaborative specific competences" (Ibáñez & Delgado-Kloos, 2018, p. 121).

Participants claimed that individual attempts could not encourage AR technology integration; financial support, training and evaluation were needed. Likewise, to ensure full access to the required technology by both faculty and students, infrastructure and technical support were required.

6.3.1.3.2 Pedagogy

As discussed in section 2.9.7, pedagogy plays a crucial role in the employment of AR technology in the educational context. Some researchers believe that neglecting to address the pedagogical principles that guide the use of emerging technology for teaching and learning was one of the problems related to technology integration (Okojie et al., 2006;

Saltan & Arslan, 2017). Pedagogy is about the practice of teaching that deals with theories and how these enhance student learning outcomes. Wang et al. (2018) posit that many coordinated efforts need to be considered to meet institutional acceptance of AR-based education, such as the establishment of a practical pedagogy. As discussed in section 2.3.5.5, a variety of educational theories are aligned with AR technology, such as situated learning, game-based learning, inquiry-based learning, constructivist learning, and connectivism.

Regarding the outcomes in this study, participants claimed that it is vital to take care of the pedagogical side as AR will be used in an educational environment, which deals with various fields and different types of students. The respondents from both the educational context and AR experts confirmed that pedagogical theories and practices must be considered to achieve the benefit of adopting AR technology. In the context of this research project, applying pedagogical principles is essential in the use of these technologies in an educational setting. The need for ascertaining which theory and practice, to guide the instructors before the adoption of AR, have been incorporated into the framework for higher education in SA as a critical success factor.

This result aligns with the views of Champney et al. (2015, p.260) who highlighted the need for "learning theories (e.g., situated learning theories, constructivist theories) to guide the design of AR solutions" to increase the value of AR in the educational context. This finding corroborates the ideas of Radu (2014, p. 1541), who suggested that "several topics need to be addressed in order to ease the adoption of this technology into school classrooms. First, AR experiences need to be designed with curriculum and pedagogy in mind." Moreover, the present findings are consistent with another study (Hantono et al., 2018) which found that the main thing to consider when developing AR in education is the pedagogical aspect and the interaction between the user and AR application.

6.3.1.4 Technology-Related Factors

This section discusses how technology-related factors affect AR adoption. The findings of this study show that technology-related factors (design and usability) are vital for the adoption of AR in Saudi universities.

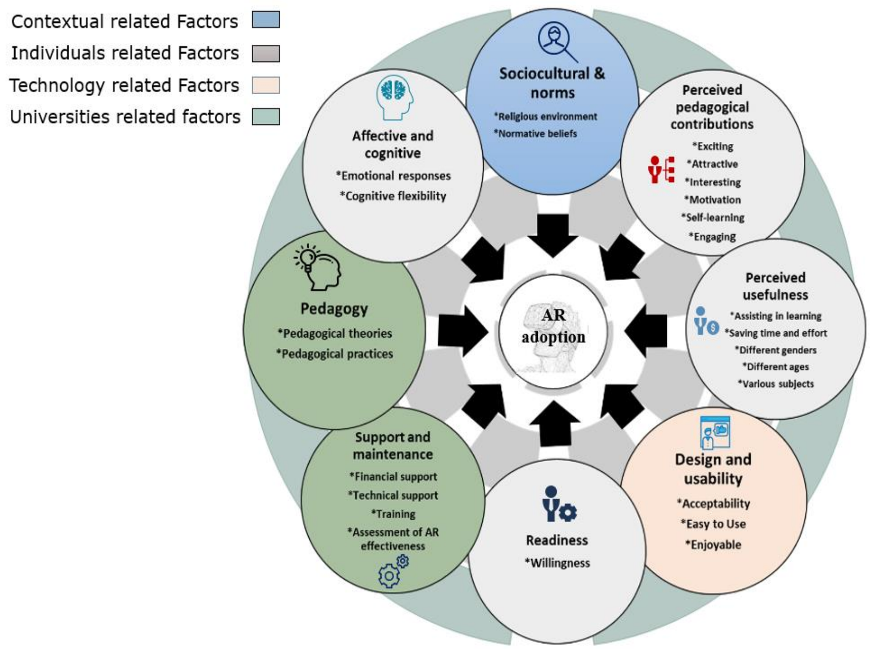
6.3.1.4.1 Design and Usability

As discussed in section 2.9.5, the literature claims that AR design and usability are critical success factors in implementing AR technology in education (Akçayır & Akçayır, 2017; Radu, 2012; Radu, 2014). Design and usability factors or the risk that users will reject the system must also be measured in any technology adoption (Davis, 1989). The work of Venkatesh et al. (2003) supports the view that perceived ease of use of a system will determine the system acceptance. Furthermore, the user experience associated with technology use, such as an enjoyable experience, influences the user's behavioural intention to continue using a system (Venkatesh et al., 2003). Preliminary results of the Theng et al. (2007) study revealed that the intention to use AR in learning was affirmed and influenced indirectly by perceived usability. Pérez-López and Contero (2013) argue that system usability is one factor that needs to be considered when adopting any new technology to provide a successful learning experience with AR.

The results of this research show that the use and adoption of AR technology for teaching and learning in the SA higher education system relies on its characteristics. Moreover, the participants highlighted the fact that AR is easy to use and available for use by most of the targeted users; some noted that most AR applications are available in smart devices, and there is no difficulty in understanding the application interface. Some indicated that flexibility in using this technology is essential. There are some obstacles and difficulties to interactions with the system in the early stages, but it will usually be improved later. Usability is an essential issue for the future integration of AR. In line with the quantitative results, the interview revealed that other reasons for accepting and integrating AR in education are due to it being attractive and enjoyable. Interview responses also pointed out that it is essential to attract users because when students and lecturers experience the enjoyment associated with the use of AR technology, they may feel satisfied and adopt it. The interviews further indicate that AR designers must not create just working applications, but also consider user experience goals such as enjoyment.

Similarly, Tao (2018) found that AR applications and functions need to be enhanced to provide an enjoyable experience for users to facilitate user adoption. The successful design of AR to ensure its usability is highly encouraged in literature. For example, Cheng and Tsai (2013) claimed that AR technology requires comprehensive user interaction and, therefore, usability factors must be addressed. According to Rasimah et al. (2011), more attention must be paid to the usability of AR applications to introduce them to users successfully. Moreover, Dalim et al. (2017) claimed that the introduction of AR easy to use technology has the potential to be accepted by those individuals who have not used it before because AR fundamentally creates a new experience.

The framework includes these factors and items that were evaluated and confirmed by academic staff, e-learning staff, and AR experts as highly crucial for AR incorporation. These factors are rigorous and robust because a series of thorough and extensive measures have been taken in their examination. This list of factors is also unique because no other study in the literature has offered such a wide variety of factors promoting the integration of AR technologies in universities.



AR Framework for Universities in SA ARFSAU (Final Version)

The ARFSAU framework for universities in SA could be used as a blueprint and an action plan for incorporating AR environments in universities in SA. The suggested framework would make it easier for educational decision-makers to integrate AR into a teaching setting for the requirements of students.

6.3.2 Research Question Two

The perceptions of stakeholders (students, lecturers, and e-learning staff) in this question in instructional AR are primarily focused on the benefits of AR implementation. This study is able to contend that there is a great perception and awareness among students and faculty members of the usefulness and pedagogical contributions of AR (see section 4.7.1.2 and section 4.7.2.2). Perceived usefulness and perceived pedagogical benefits of AR were presented in the final ARFSAU framework as fundamental factors to adopt AR in Saudi higher education. These two factors were derived from investigating the students, lecturers, and e-learning staff's perceptions in the quantitative phase (see section 4.7.1.5.1 and section 4.7.2.5.1).

6.3.2.1 Students' Perceptions

Undergraduate and postgraduate students studying in a college or a university, the consumers of educational technology in SA, participated in this study, as well as the contributors to the teaching method process. Students perceived that using AR technology as a teaching method would be a leap in the quality of education in SA. Students, however, feel that they are not yet ready to use AR technologies in their learning and teaching and prefer not to rely entirely on AR and have an educator as their primary source of knowledge (see section 4.7.1.8).

Some students believe that because this technology was created for games, they do not think that they will take it seriously in the educational field. Some students are uncomfortable in adopting AR as they believe the incorporation of AR in higher education may create barriers for some students who do not have the budget to own devices that operate AR. Also, AR may be a reason for lack of attention in lectures.

What is interesting in this study is that the students are enthusiastic about educational AR as they believe this could be a solution to increase self-learning and make theoretical curricula more practical through making the transition to AR learning methods.

6.3.2.2 Faculty Members and E-Learning Staff Perceptions

Lecturers and e-learning staff, as the educational guides of the AR experience of students, believe that if educators utilise AR in teaching and learning, this could enhance motivation, self-learning and learning outcomes. It was found that lecturers and e-learning staff were very conversant with AR technology, and they would likely integrate and use AR in their teaching and learning soon (see section 4.7.2.3).

Some participants reported that members of the faculty needed to understand the power of this technology and develop their knowledge of producing useful material to help students embrace the technology. Some e-learning staff believe it will be a tremendous challenge to establish a reliable foundation for AR in universities and stressed the need for AR designers to design learning materials suitable for Saudi society (see section 4.7.2.7). Some participants expressed the belief that educational AR learning requires sufficient funds, equipment, special workshops for students and lecturers, and well-built infrastructure.

6.3.3 Research Question Three

This study sought to assess the educational AR experts' perceptions towards the developed AR framework. Experts' responses to this question concentrate mainly on the AR framework and evaluating and confirming the AR adoption factors. The educational AR experts' perceptions were examined in the second phase in order to explore the AR adoption factors further and refine and evaluate the second draft of the AR framework resulting from the survey responses.

The results show that the use of AR technology in university education is welcomed by Saudi universities and that SA's cultural restrictions do not constitute a significant obstacle to practical use (see section 5.6.2). Although specific barriers were stated, educational AR experts were generally optimistic and passionate about the possibility of the integration of modern technology such as AR technology into education. This is consistent with the present Vision 2030 reorganisation of the Saudi landscape, which the Saudi people are looking forward to realising.

Furthermore, the research found that, based on the educational AR experts' point of view, all the main factors from the revised AR framework were acceptable with an additional factor and an emerging sub-factor (see section 5.9). An examination of the perceptions of the AR experts towards the AR framework in the interviews, showed a range of responses, all confirming the importance of the factors which constituted the final framework. Interviewees emphasised the importance of each factor by their confirmation and level of agreement.

Also, pedagogical AR experts were consulted to weigh the factors identified based on the most influential factor found in the adoption of AR at Saudi universities (see section 5.9).

The results show that the highest-rated factors based on the experts' vision are perceived pedagogical contribution, followed by perceived usefulness factor, followed by usability and design, followed pedagogical theories and practices, followed by technology readiness and willingness, support and maintenance, followed by Affective and cognitive factors. The lowest rated factors were sociocultural and norms factors.

6.4 Recommendations

Based on the results presented in this study, there are a set of actionable recommendations that may assist and promote the integration of AR technology and other similar technologies in SAn universities. It is expected that the implementation of these factors would guide decision-makers and researchers in the areas of IS technology adoption in the higher education system to incorporate AR and other similar technologies successfully. These recommendations to ensure the effectiveness and efficiency of AR integration into SA universities are summarised in Figure 88.

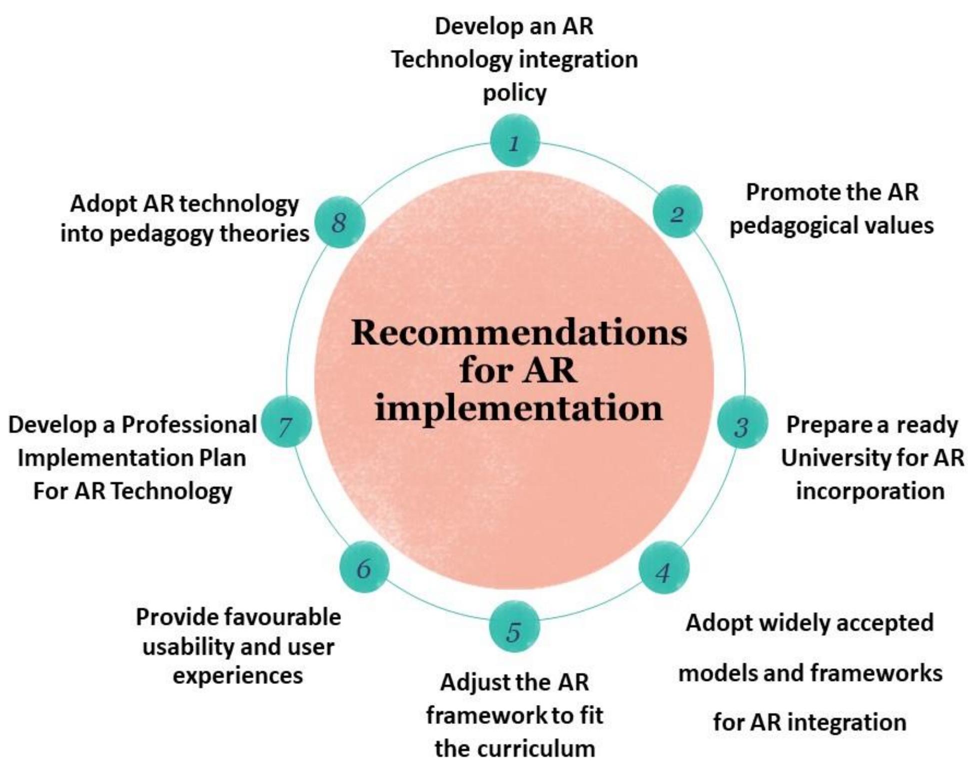


Figure 88: Summary of recommendations for educational AR in Saudi Arabian universities

6.4.1 AR Technology Integration Policy

AR technology, as an educational tool, must be accepted by the members of society to be effective. Therefore, policy, protocols and guidelines, which consider the strictures of SAn society and culture, must be developed before integrating AR technology to enable this technology to be entirely accepted. Safely using agreed protocols, and explaining how the AR systems will be used, assist in the handling of the AR systems for defined needs in higher education. These protocols specifically concern the religious, moral and ethical standards that are necessary for the users to become responsible for AR usage in higher education in SA. Some of these religious and ethical standards involve the use of a female character, violent images, privacy (e.g. using cameras) and maintaining security. Thus, before using AR technology, universities, faculty members, and students must become familiar with these protocols and understand them. Concerning the personal normative beliefs, the analysis findings also show that faculty members and students are more likely to implement AR technology when they are aware that their superiors and significant people are encouraging this implementation within the universities. Thus, close friends and colleagues who already apply AR technology should reveal their experiences to encourage and promote personal norms to engage in AR usage.

6.4.2 Adoption of AR Technology Frameworks

From this research, it was shown that frameworks for incorporating AR in Saudi higher education were severely lacking. As mentioned in Chapter 2, widely accepted models and frameworks for technology adoption increase the confidence of universities in implementing new technologies. These provide a blueprint for how the AR implementation structure in the higher education system can be effectively applied to use emerging technology and reduce risk efficiently.

6.4.3 Awareness of AR Pedagogical Values

It is highly recommended that more effort should be made to promote the pedagogical contributions and values of AR technology in education to fully implement it in education.

Providing stakeholders with more insight regarding the pedagogical benefits of AR and its implications might lead to the improvement in the integration of AR within educational settings. Based on the Diffusion of Innovation Theory, perceiving the pedagogical benefits and usefulness of AR by more faculty members and university managements in the HE disciplines can lead to the spreading use of AR in university education quickly. Efforts should be made to promote positive beliefs/attitudes and understanding of the pedagogical values of AR and emphasis should be placed on enhancing the benefits of this technology to target users. Thus, decision-makers, department heads, academic staff, and students should be enlightened about the pedagogical AR opportunities via conferences, workshops, AR technology demonstrations, posters, seminars, staff emails, and promotion on Blackboard (or relevant learning management systems). Classroom visits are also encouraged to promote the exchange of ideas and experiences about the educational benefits and integration of AR.

Educators are more likely to deploy AR technologies in their classroom once they know about it. Also, it is recommended that online communities be established to share teaching and learning experiences with AR technology. Support for AR technology, especially for the department heads, e-learning staff, and lecturers, to communicate its benefits so that this technology can be easily provided in educational institutions in SA. The belief of essential people in SA higher education in new technologies is evidence of professionalism and professional development and will make SA universities seek to adopt new technologies and show interest in AR.

6.4.4 University Readiness and Willingness

The readiness and willingness of universities, lecturers and students are crucial in adopting the AR tool to improve the process of teaching and learning. Such innovative technology calls for reform and a new educational approach at all levels. Through planning infrastructure and programs, universities should be prepared; hence, universities need AR expertise in the first stages of the integration. Also, the knowledge gap in AR technology among universities must be bridged. Universities should prepare curriculum-aligned educational AR content and the environment by designing content that suits different subjects and university levels to make AR more impactful and widely acceptable in the SA higher education system. To increase willingness to adopt AR in SA universities, faculty members should be encouraged by linking their use of AR to rewards and promotion (i.e., salary increase, reduced teaching load).

6.4.5 Usability and User Experiences

It is recommended that university management, instructors and administration leverage students' high level of acceptance via deploying vital techniques to provide positive emotional aspects and cognitive responses to encourage them in this technology to create a pleasant and productive AR learning environment in the SA universities. Throughout the early stages of AR adoption, universities are strongly encouraged to collaborate with specialist AR software and service firms to harness outside expertise and technology. AR needs to be low in complexity and applicable for adults and young people in all stages of higher education. The design of AR content and applications should ensure acceptability, ease of use, and enjoyment by both staff and students and should be free from potential errors and difficulties that might confront users during teaching and learning sessions. It is recommended to involve people in AR pilot implementation projects at an early stage of the integration, to be aware of the issues in users' emotional and cognitive reactions to address and resolve them. A better understanding of these obstacles could enhance university results and the quality of the information underlying university leadership choices.

6.4.6 Professional Implementation Plan for AR Technology

A professional support and maintenance plan is needed to prepare the universities for the integration of AR. An implementation plan will be expected for each university to clarify how the university will begin to capture the benefits of AR while building up its capacity to extend its use. Dedicated teams would be required to build the infrastructure for the growth and creation of this new medium and to sustain the AR content. Required equipment, technical support, training academic staff and students to use AR, needs to be provided to ensure that there are positive attitudes towards these technologies and that it promotes an environment where AR use is acceptable. In addition, providing financial support is essential. Table 66 includes useful information for stakeholders to estimate the approximate costs to implement AR technology in a university.

Table 66: An approximated cost of implementing AR in a university

General requirements	Discerptions	The approximate cost (These prices are subject to change over time and from one country to another.)
Application development	This is related to the cost of building and develop an application for educational purpose.	The estimated cost is $5,000–$10,000.
3D Modelling and UI/UX and graphic design.	After developing an AR application, an AR software development kit is needed. Learning contents and graphics need to be modelled and designed in 3D by a 3D designer and experts in mobile UX/UI design.	The estimated cost starts in India at $30 an hour and goes all the way up to $150 an hour in North America to hire a 3D designer.
Devices	This is related to the cost for the type of devices and hardware that can be used for running the AR application.	iPad and smartphones capable of AR start around $400. AR wearable devices start around $600 to $1900.

The participants expressed their need for training, to get students and instructors comfortable with educational tools. Without offering the proper guidance on how to use these AR tools, faculty members and students are not encouraged to promote new technology. Universities need to organise technical training programs to increase the technical skills of their academic staff. A key goal is to support both learners and educators with digital literacy skills. Training should not be restricted to educators acquiring abilities for managing specific programs, such as Aurasma, but should be provided following the TPACK model (Mishra & Koehler, 2006), that is to say, providing training to enable lecturers to obtain technical expertise about AR, content understanding, pedagogical knowledge, and its integration in educational practices.

Also, it is highly recommended that research should be conducted, and iterative assessment of the technology should be carried out to provide evidence-based data about the effectiveness of AR for learning. Independent monitoring is needed to implement AR on a large scale successfully. Monitoring and assessing AR can allow stakeholders to determine what difference AR makes and provide useful information to help them enhance their performance.

6.4.7 Pedagogy Theories and AR Technology

The implementation of AR in education relies on pedagogical approaches and principles to guide the integration and acceptance in SA higher education. Using AR technology needs not only experience in how to use these tools, but also requires involving modern pedagogical paradigms and strategies (Johnson et al., 2011; Veletsianos, 2010). Therefore, underpinning AR technology with learning theories is needed to be taken into consideration when AR systems are implemented in the higher education system. Universities should also consider the best practices that need to be used to integrate AR with curricular material and guarantee the successful integration of AR to provide a high standard of pedagogical quality.

6.5 Research Contributions

This research makes several contributions to the field of higher education, including educational AR technology. Its overarching contribution lies in identifying the perceived utility of AR as a learning tool in SAn higher education and the development of a comprehensive framework which merges factors derived from the three phases. This research is one of the first studies in SA to research educational AR on such a broad scale. The research employed a mixed-method approach that has proven suitable for the investigation of AR technology as a tool for learning in SA, although limitations have been encountered. The framework is also the first to be developed in the context of a developing country with the Vision 2030 plan to reduce oil dependency, diversification of its economy and the promotion of public services such as health, education, infrastructure, recreation and tourism, in SA. The Saudi Government's Vision 2030 is to have at least five Saudi universities ranked internationally in the best universities in the world, in part by adopting technological innovations like AR.

The outcomes of this research align with the new Vision for 2030, as proposed by the SAn Government, and education is one of the main concerns in this vision. Adopting technology like AR cannot be achieved without outlining factors that encourage the successful implementation of AR technology; hence the need for a comprehensive framework to guide the adoption. The ARFSAU assists SAn universities to make better use of the many advantages that AR can bring to achieve excellence in digital learning. The study also contributes to the theoretical knowledge in this area by offering recommendations that will guide the universities in developing countries, such as SA, in their implementation of AR technology, as discussed in 6.4. Stakeholders of other developing countries planning AR initiatives, especially in the GCC countries, could take advantage of these recommendations.

The incorporation of realistic perceptions of the participants added valuable information about these factors and the framework. The independent factors that were selected after scrutiny were incorporated into the final ARFSAU. The final eight factors, namely: sociocultural and norms, perceived pedagogical contribution, perceived usefulness, pedagogy, readiness and willingness, usability and design, support and maintenance, and affective and cognitive factors, resulting from all methods were collated to generate the final ARFSAU shown in Figure 87 above.

6.6 Research Limitations and Future Research

Although this research provides significant contributions from both a theoretical and practical perspective, several limitations to this research need to be acknowledged. These are discussed in more detail below, along with future research recommendations.

Regarding the study population, this research was conducted in public universities in SA. The focus of this study was on the universities in SA in particular. In other teaching and learning environments in SA, such as elementary and secondary schools, professional training programs and workplace learning settings, implementing AR factors and barriers might be very different. A further study could be done to examine different learning settings with distinct features (e.g. private universities, elementary and secondary schools) or in a different cultural context.

This research conducted a cross-sectional study to collect data from students at universities, faculties, e-learning staff, and AR professionals. Future research is recommended for a longitudinal study to provide an understanding of the interrelationship of the various factors that may influence the integration of AR technology.

The survey method used in this research also has some limitations. AR is still a new technology, and some of the participants were not familiar with it, so it was difficult for the researcher to find data from an exploratory source. Thus, the data collection was more subjective data. A lack of knowledge about some of the AR concepts involved in the research led to many incomplete responses. The answers of the respondents of the students or lecturers and E-learning Staff Surveys, who have not direct experience with AR, influenced the output such as response bias. Therefore, the research spent a long time to get valid data and an acceptable responses rate. Furthermore, the study aimed to investigate the current and desired adoption of the AR environment in universities, providing eight factors (22 items). After a comprehensive review of the related literature and two stages of data collection, these factors and items were identified. However, because there is little research on AR technology in SA, other factors related to different contexts might exist, and the descriptive design does not give all the answers. Hence, further research could conduct unstructured and in-depth interviews to investigate other or more detailed factors and items that encourage universities to integrate AR.

Also, despite the latest improvements, gender roles imposed by Saudi nationals resulted in a very limited group of female interviewees, and as such, a fair representation of their involvement was hard to achieve. Also, most female respondents recruited for interviews were unwilling to communicate face-to-face, even via Skype calls. Therefore, it was difficult for the researcher to conduct face-to-face interviews to explore various perspectives, opinions, and experiences in public life.

Moreover, a shortcoming of this study is that it focuses on conceptualising educational AR technology for Saudi universities without associated implementation trials. For example, there were no observations or collection of teaching and learning materials using AR, and the data is reliant on the students, e-learning and academic staff self-assessments and perceptions. Further research might build upon the findings of this research to examine AR use and effectiveness in SA universities through experiential data from academic staff and students' perspectives. Another limitation lies in the ARFSAU itself. All the identified factors are independent. Further research can be conducted to examine the factor relations and evaluate the same framework with various methodologies and tools, such as structural equation modelling, SmartPLS and LISREL, that could lead to distinct outcomes of introducing AR in universities.

As many emerging technologies need capital intensive, the framework was developed for the Saudi higher education system, which has a thriving economy and ambition to overhaul its education system. Many less developed countries may have no such resources to implement the same framework in their higher education systems due to financial support and maintenance factors. Moreover, culture and religious factors specific to society in SA, are influential factors to be considered in the integration of new technologies there, but these factors might be different in other contexts. Further research could be conducted to examine the same framework in other developing countries to determine if the framework needs to be amplified or adjusted to suit different settings.

Educational institutions have faced widespread disruptions due to the COVID-19 pandemic. Maintaining education during further pandemics will require thoughtful, intentional, and strategic planning. Further research can be conducted to examine the implications of the integration of exemplary innovations such as AR technology as an alternative resource to a permanent solution so that the teaching and learning process is not interrupted.

6.7 Conclusion

This chapter began with a presentation of the overall findings of the research, a review of the research questions and the answers. The ARFSAU is the primary outcome of this study and includes common considerations and factors for implementing AR technology in SAn universities as found in the data collection phases. These factors were confirmed and acknowledged by the respondents as being the most important in seeking a successful outcome when integrating AR technology into universities on a broader scale. Subsequently, recommendations were derived from the ARFSAU to further assist the higher education sector and universities with the sound implementation of AR technologies in the learning environment. These include the consideration of sociocultural and norms, provision of real understanding of the pedagogical values of the AR technology as well as its usefulness in aligning educational AR technology with pedagogical theories and practices, AR design, as well as the usability, readiness and willingness, support and maintenance, and understanding the affective and cognitive factors in its implementation.

The contributions of this research fill a literature gap by providing theoretical frameworks to guide the adoption of AR and combining all critical factors in one framework. The framework is also the first to be established for SA universities that seek to embrace AR in their education. Finally, this thesis offers guidance on which aspects Saudi universities should concentrate on to guarantee successful implementation. As AR initiatives and similar technologies in higher education are expected to increase over the next few years, an increasing number of developing countries' universities will be subject to the issue mentioned in this research. Concerning its practical significance, this study has suggested that eight factors are critical for the success of AR and similar technologies integration in developing countries' universities. Study limitations were acknowledged, and directions were given for future studies. Technology has been used rapidly and creatively to sustain education and learning during the Covid-19 pandemic. AR technologies could offer solutions to enhance online university teaching with an immersive experience and interaction during and after the Covid-19 Crisis.

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APPENDICES

Appendix 1: Ethical Approval

Curtin University

Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
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Web research.curtin.edu.au

05-Jul-2017

Name: Tomayess Issa
Department/School: School of Information Systems
Email: Tomayess.Issa@cbs.curtin.edu.au

Dear Tomayess Issa

RE: Ethics Office approval
Approval number: HRE2017-0425

Thank you for submitting your application to the Human Research Ethics Office for the project **Developing, Understanding and Evaluating Augmented Reality Framework for Universities in Saudi Arabia**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **05-Jul-2017** to **04-Jul-2018**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Alahmari, Muteeb Saad	Student
Issa, Tomayess	CI

Approved documents:

Document

Appendix 2: Online Survey Consent Form

CONSENT FORM

HREC Project Number:	HRE2017-0425
Project Title:	Developing, Understanding and Evaluating Augmented Reality Framework for Universities in Saudi Arabia
Principal Investigator:	Dr Tomayess Issa
Student Researcher:	Muteeb Saad Alahmari
Version Number:	01
Version Date:	**9 May 2017**

- I have read (or had read to me in my first language) the information statement version listed above, and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Note: All parties signing the Consent Form must date their own signature.

Appendix 3: Online Survey Questions

Curtin University

Dear Sir/Madam

I am conducting research regarding Developing, Understanding and Evaluating an Augmented Reality Framework for Universities in Saudi Arabia. This research involves a survey, which will take less than 10 minutes to complete. This survey contains four sections. Please read each statement and then circle the number or tick the box, which shows how you feel.

Augmented reality is an integration of digital information with user environment in real time.

Click on the following link to see some examples of Augmented reality in education:

https://www.youtube.com/watch?v=7G3H3lmCWIE

If you feel uncomfortable in answering certain questions, please feel free to disregard them.
We would appreciate it if you could complete this survey within a week. However, if this is too short a space of time, please respond as soon as you are able.

Participation in this research is completely voluntary and your responses will be completely anonymous. Participants may withdraw at any time without prejudice or negative consequences, and do not need to provide a reason.

By completing this survey, you are consenting to participate.
Any information provided by you through the survey will be held as strictly confidential. Information will not be disclosed to any parties besides the researchers, unless required to do so by law.

Finally, the researchers will ensure that published material will not contain any information that can identify you or your organisation.

We encourage you to participate because this research will provide valuable insights into students, teachers, and learning departments stuff's attitudes toward Augmented Reality technology in the higher education sector in Saudi Arabia. This research will help us to develop the higher education sector in Saudi Arabia. Your assistance in this research is greatly appreciated and is crucial for the success of its findings.
Your interest and consideration are greatly appreciated. If you need any additional information from us, please let us know by contacting Tomayess.Issa@cbs.curtin.edu.au (+61 8 9266 7682) or M.alahmari4@postgrad.curtin.edu.au (+61432405542)

Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2017-0425). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Thank you in advance
Yours faithfully,

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Students Survey

Q1 **Part 1: Under this section, the researcher will examine the participants' demographic information and background**
What is your age?

- ○ 18 - 23
- ○ 24 - 28
- ○ 29 - 33
- ○ 34- 38
- ○ 39 - 44
- ○ 45 - 50
- ○ 50 and above

Q2 **Gender**

- ○ Male
- ○ Female

Q3 **What is your Job Title?**

- ◯ student
- ◯ Lecturer (academic staff)
- ◯ E-Learning departments' staff
- ◯ Other - please specify

Q4 **Please tick your main field(s) of study/work**

- ◯ Accounting
- ◯ Business Law
- ◯ Economics and Finance
- ◯ Information Systems
- ◯ Information Technology
- ◯ Computer Science
- ◯ Management
- ◯ Marketing
- ◯ Health Sciences
- ◯ Humanities
- ◯ Science and Engineering
- ◯ Art and Design
- ◯ Other – Please specify

Q5 **Please tick your year(s) of study at the University**

- ◯ Year 1
- ◯ Year 2
- ◯ Year 3
- ◯ Year 4 or more

Q6 **Please tick your highest education level**

- ◯ preparation years/ Professional Certificate
- ◯ Diploma
- ◯ Bachelor's Degree
- ◯ Post Graduate Diploma
- ◯ Master's Degree
- ◯ Doctorate Degree

Q7 **Tick your computer experience level**

- ◯ Beginner
- ◯ Intermediate
- ◯ Advanced
- ◯ Expert

Q9 **Tick your interest in technology**

- ◯ High
- ◯ Medium
- ◯ Low

Q10 **Tick your level of using a smartphone**

- ◯ High
- ◯ Medium
- ◯ Low

Q11 **Tick your level of using tablets**

- ◯ High
- ◯ Medium
- ◯ Low

Q12 **Tick your level of using laptops.**

- ◯ High
- ◯ Medium
- ◯ Low

Q13 **Tick your prior knowledge about AR technology.**

- ◯ High
- ◯ Medium
- ◯ Low

Q14 **Part 2:** Under this section, the researcher will examine the participants' perception towards using Augmented Reality technology and its pedagogical contributions in higher education:
To what extent do you agree with the following statements?

AR Technology use in Saudi Arabia higher education sector:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
..Is expected to achieve the intended use	◯	◯	◯	◯	◯
..Is much better than traditional learning method	◯	◯	◯	◯	◯

..Is suitable for different ages	○	○	○	○	○
..Is suitable for different genders	○	○	○	○	○
..Is appropriate to apply in various subjects	○	○	○	○	○
..Is saving time and effort for the teachers and students	○	○	○	○	○
..will assist in learning and teaching	○	○	○	○	○
.. Is a cooperative learning tool	○	○	○	○	○
..is a motivating learning method	○	○	○	○	○
…does not consider the individual differences among students	○	○	○	○	○
…will help improve learning outcomes	○	○	○	○	○
…will promote self-learning	○	○	○	○	○
..will prevent communications between students and lecturer	○	○	○	○	○

Q16 **Do you have any comments regarding the AR use in Saudi Arabia higher education sector?**

____

Q17 **Part 3:** Under this section, the researcher will examine some of the factors to take into consideration when integrating AR in the Saudi higher education sector such as user usability, interaction with the computer, evaluation, sustainability, and willingness of integration.

Please indicate your level of agreement to each statement:

Usability

AR use in my learning:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)

…will prevent to accomplish learning tasks more quickly.	○	○	○	○	○
…is unnecessarily complicated	○	○	○	○	○
.. will be easy to evaluate	○	○	○	○	○
…will be easy to use	○	○	○	○	○
…will be useful	○	○	○	○	○

Q37 **Willingness to use**

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I will use AR for learning activities	○	○	○	○	○
I do not want to use AR in future	○	○	○	○	○
I'm willing to learn more about AR technology	○	○	○	○	○
I'm willing to use AR in my learning	○	○	○	○	○
I like to use AR in my learning at the university	○	○	○	○	○
I will recommend to my colleagues to use AR	○	○	○	○	○

Q20 **Comments: Please add other comments on other factors that might facilitate or influence the integration of AR in the universities:**

Q21 **Part 4:** Under this section, the researcher will examine some of the influential factors such as Cognitive factors, Emotional factors, social factors, and beliefs.

Please indicate your level of agreement to each statement:

Cognitive Factors

learning via AR use:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
…will give me much pressure.	○	○	○	○	○
…will require much mental effort to understand the content	○	○	○	○	○
…is inflexible	○	○	○	○	○
…will enable me to receive information quickly	○	○	○	○	○
… will help me to remember the learning material easily	○	○	○	○	○
…will help me to keep my attention on the learning task	○	○	○	○	○
…will assist me to be so concentrating on the learning	○	○	○	○	○
…will help me to improve my spatial skills. (8)	○	○	○	○	○
…will be stressful	○	○	○	○	○

Q22 **Emotional and affective factors**

Augmented reality as a learning tool:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
...Is pleasing	○	○	○	○	○
...Is taking less time to deliver the information	○	○	○	○	○
...Is engaging	○	○	○	○	○
...Is meeting my satisfaction and goals	○	○	○	○	○
…Is attractive	○	○	○	○	○
…Is frustrating	○	○	○	○	○
..Is confusing	○	○	○	○	○
.. will assist my learning efficiency	○	○	○	○	○
.. will increase my learning performance	○	○	○	○	○
.. will increase my learning motivation	○	○	○	○	○

Q23 **Social factors**

Integrating the AR system in Saudi Arabia higher education sector:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
..Is inconsistent with the values and customs of Saudi Arabia	○	○	○	○	○
..needs to be suited to Saudi Arabia's religious environment	○	○	○	○	○

..will cause ethical concerns	○	○	○	○	○
…is essential for me as a university student	○	○	○	○	○
.. Is the future of Saudi Arabia higher education and meet with the new vision of the Saudi government in 2030?	○	○	○	○	○

Q24 **Beliefs**

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I want to do what most of the students think I should do concerning using AR in my learning	○	○	○	○	○
I want to do what my teachers, in particular, thinks I should do regarding using AR	○	○	○	○	○
People, who are important to me, would approve my using AR in my learning.	○	○	○	○	○

Q40 Comments: Please add other comments on other factors that might facilitate or influence the integration of AR in the universities:

____

Lecturers and E-learning Staff Survey

Q1 **Part 1: Under this section, the researcher will examine the participants' demographic information and background**

What is your age?

- ◯ 18 - 23
- ◯ 24 - 28
- ◯ 29 - 33
- ◯ 34- 38
- ◯ 39 - 44
- ◯ 45 - 50
- ◯ 50 and above

Q2 **Gender**

- ◯ Male
- ◯ Female

Q3 **What is your Job Title?**

- ◯ student
- ◯ Lecturer (academic staff)
- ◯ E-Learning departments' staff
- ◯ Other - please specify

Q4 **Please tick your main field(s) of study/work**

- ◯ Accounting
- ◯ Business Law
- ◯ Economics and Finance
- ◯ Information Systems
- ◯ Information Technology
- ◯ Computer Science
- ◯ Management
- ◯ Marketing
- ◯ Health Sciences
- ◯ Humanities
- ◯ Science and Engineering
- ◯ Art and Design
- ◯ Other – Please specify

Q6 **Please tick your highest education level**

- ◯ preparation years/ Professional Certificate
- ◯ Diploma
- ◯ Bachelor's Degree
- ◯ Post Graduate Diploma
- ◯ Master's Degree
- ◯ Doctorate Degree

Q7 **Tick your computer experience level**

- ◯ Beginner
- ◯ Intermediate
- ◯ Advanced
- ◯ Expert

Q8 **Tick your educational usage of technology in your professional activities.**

- ◯ High
- ◯ Medium
- ◯ Low

Q9 **Tick your interest in technology**

- ◯ High
- ◯ Medium
- ◯ Low

Q10 **Tick your level of using a smartphone**

- ◯ High
- ◯ Medium
- ◯ Low

Q11 **Tick your level of using tablets**

- ◯ High
- ◯ Medium
- ◯ Low

Q12 **Tick your level of using laptops.**

◯ High

◯ Medium

◯ Low

Q13 **Tick your prior knowledge about AR technology.**

◯ High

◯ Medium

◯ Low

Q15 **Part 2:** Under this section, the researcher will examine the participants' perception toward adopting Augmented Reality technology and its [1] pedagogical contributions in higher education. Also, some of the factors such as acceptance, evaluation, interaction with computer and usability will be examined.

[1] Practice of education to enhance the student's learning outcome.
To what extent do you agree with the following statements?
AR use Technology in Saudi Arabia higher education sector:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
..Is expected to achieve the intended use	◯	◯	◯	◯	◯
..Is much better than traditional learning method	◯	◯	◯	◯	◯
..Is suitable for different ages	◯	◯	◯	◯	◯
..Is suitable for different genders	◯	◯	◯	◯	◯
..Is suitable to apply in various subjects	◯	◯	◯	◯	◯
..Is saving time and effort for the teachers and students	◯	◯	◯	◯	◯
..facilitates learning and teaching	◯	◯	◯	◯	◯

.. Is a cooperative learning tool	○	○	○	○	○
..is a motivating learning method	○	○	○	○	○
…considers the individual differences among students	○	○	○	○	○
… will help to evaluate the student learning outcome	○	○	○	○	○
…will help to improve learning outcome	○	○	○	○	○
…will promote self-learning	○	○	○	○	○
.. will reduce communication between students and lecturer	○	○	○	○	○
… is more interesting	○	○	○	○	○
… is exciting	○	○	○	○	○
...is attractive	○	○	○	○	○
…..is enjoying	○	○	○	○	○
… is needlessly complicated	○	○	○	○	○
… is easy to use	○	○	○	○	○
…is easy to evaluate	○	○	○	○	○
…is useful	○	○	○	○	○
…will allow me to do things that I cannot easily do now	○	○	○	○	○
Overall, I feel sure about my attitude toward using AR in education	○	○	○	○	○

Q16 **Do you have any comments regarding the AR use in Saudi Arabia higher education sector?**

____

Q18 **Part 3:** Under this section, the researcher will examine some of the factors such as guidelines for integration, technological infrastructure, user awareness and sustainability. **Please indicate your level of agreement to each statement:**

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
There is awareness about Augmented Reality among students and faculty members to adopting this technology in education	○	○	○	○	○
Students must have high user acceptance of AR technology	○	○	○	○	○
Faculty members and staff must have high user acceptance of AR technology	○	○	○	○	○
Government policies should encourage AR use in the higher education sector	○	○	○	○	○
Funding by the government and a sufficient budget is vital for AR integration	○	○	○	○	○
Universities in Saudi Arabia support AR use	○	○	○	○	○
University funding and budget sufficiency is important for AR integration	○	○	○	○	○
Saudi Arabia Universities must have high-speed internet connectivity	○	○	○	○	○
The university must have sufficient hardware	○	○	○	○	○
The university must have sufficient software	○	○	○	○	○
Saudi Arabia Universities must provide technical support and maintenance to AR use via users	○	○	○	○	○

AR training is needed to integrate it into my courses	○	○	○	○	○
Testing AR systems is needed to assure that the system is easy for students and faculty members	○	○	○	○	○
Saudi Arabia Universities should encourage appropriate assessment and evaluation of the impact of AR on teaching and learning	○	○	○	○	○

Q20 **Comments: Please add other comments on other factors that might facilitate or influence the integration of AR in the universities:**

____

Q25 **Part 4: Under this section, the researcher will examine some factors such as the willingness of integration, social influences, culture and beliefs.**

Please indicate your level of agreement to each statement

Social factors

AR use in Saudi Arabia higher education sector

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
..Is inconsistent with the values and customs of Saudi Arabia	○	○	○	○	○
..needs to be suited to Saudi Arabia's religious environment	○	○	○	○	○
..can cause ethical concerns	○	○	○	○	○
… will be obliged to apply it in my professional activities	○	○	○	○	○
.. Is the future of Saudi Arabia higher education and meets with the new vision of the Saudi government in 2030	○	○	○	○	○

Q26 **Beliefs**

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I want to do what most of lecturers and professors think I should do concerning using AR in teaching	○	○	○	○	○

I want to do what my university head department and dean, in particular, thinks I should do regarding using AR	○	○	○	○	○
People who are important to me would approve my using AR in my work	○	○	○	○	○

Q27 **Willingness of integration**

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I am willing to use AR for activities concerning the teaching of course materials.	○	○	○	○	○
When I inform of using AR in teaching, my initial reaction would be to feel resistant	○	○	○	○	○
I do not want to use AR in future	○	○	○	○	○
willing to learn more about AR technology	○	○	○	○	○
willing to use AR in my teaching and professional activities	○	○	○	○	○
AR should be introduced in my university	○	○	○	○	○
AR is on our strategic roadmap to develop higher education and students learning outcome	○	○	○	○	○
AR learning tools are the best choice for teaching my subject area	○	○	○	○	○
I will recommend using AR with my other colleagues	○	○	○	○	○
I should avoid making changes because things could get worse.	○	○	○	○	○

Appendix 4: Interview Questions

AR interview

My name is Muteeb Alahmari. I am a doctoral candidate in the school of Management at Curtin University in Western Australia. I am conducting a study for my thesis regarding Developing, Understanding and Evaluating an Augmented Reality Framework for Universities in Saudi Arabia. My research aims to identify factors that will have the most influence on AR adoption. You have been selected as a potential and important participant in this study. Your participation is solicited, although your participation is strictly voluntary and all data that you provide will be confidential. If you decide to participate, you will be asked to complete a couple of questions about influence factors of AR from your perspective and experience. The interview will start with general questions regarding your experience of AR and its use in higher education and then asking you to evaluate my framework about AR adopting factors. Your participation is anonymous, and your identity will not be published or disclosed. This research aims to facilitate the integration of augmented reality by providing a framework for adopting AR. The findings of this study will provide useful points of reference for decision-makers in the government and education and raise their awareness of the need to introduce more and relevant technology methods, such as AR, into the learning environment. I will keep you updated on my results of this study and at the end of my degree, I will share with you my framework.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2017-0425). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au."

Your help and cooperation is highly appreciated

With kind regards,

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What is your occupation?

Age

Qualification

Years in the current job

Q6 I would like to start with your level of knowledge and experience with Augmented Reality technology.

Indicate your level of knowledge and experience of this technology. Below, please elaborate on this knowledge and experience.

____

____

Q8 Augmented Reality technologies are used in many sectors such as health, marketing, architecture, design and games.

Do you think Augmented Reality could be introduced to Saudi universities? Below, please indicate the reason(s) for your response.

____

____

Q10 From your experience, what are the important factors that we should consider before incorporating Augmented Reality into teaching and learning at Saudi Arabia universities?

____

____

Q11 Sociocultural factors and norms theme

The implementation of Augmented Reality in higher education is influenced by the religious environment and social and institutional culture.
From your perspective, how might the religious environment of Saudi Arabia influence the implementation of Augmented Reality in Saudi universities? Provide an example if possible.

____

____

Q12 Please rate the importance of sociocultural factors and norms to the implementation of Augmented Reality.

- ◯ Unimportant (1)
- ◯ (2)
- ◯ (3)
- ◯ (4)
- ◯ Important (5)

Q13 Do you think the social and institutional culture of Saudi Arabia might influence the implementation of Augmented Reality in Saudi universities?
Below, please indicate the reason(s) for your response.

____

____

Q15 Do you think the use of Augmented Reality in Saudi universities will raise ethical concerns? Below, please indicate the reason(s) for your response.

____

____

Q17 Is Augmented Reality suitable for both genders? Below, please indicate the reason(s) for your response.

____

____

Q19 From your experience, to what extent do the normative beliefs of others such as friends, lecturers, heads of department, and deans of college who motivate or encourage the implementation of Augmented Reality, influence lecturers' and students' decisions to adopt Augmented Reality in teaching and learning? Below, please indicate the reason(s) for your rating.

____

____

Q21Perceived usefulness theme
Augmented Reality technology is useful to the learning process in a variety of ways. How might the perceived usefulness of Augmented Reality technology in teaching and learning affect the integration of this technology?

____

____

Q22 Please rate the importance of the perceived usefulness of Augmented Reality technology factor.

- ○ Unimportant (1)
- ○ (2)
- ○ (3)
- ○ (4)
- ○ Important (5)

Q23 Below, please rate the usefulness of implementing Augmented Reality in Saudi higher education.

- ○ Extremely useful (1)
- ○ Very useful (2)
- ○ Moderately useful (3)
- ○ Slightly useful (4)
- ○ Not at all useful (5)

Q24 Pedagogy and perceived pedagogical contribution theme

Augmented Reality technology can make a range of pedagogical contributions to education. Do you agree that the perceived pedagogical contributions of Augmented Reality technology to teaching and learning is an important factor to facilitate the adoption of this technology? Below, please indicate the reason(s) for your response.

____

____

Q26 Please rate the importance of considering the pedagogical contributions when designing and implementing Augmented Reality.

○ Unimportant (1)

○ (2)

○ (3)

○ (4)

○ Important (5)

Q27 From your experience, do you think it essential that pedagogical approaches (e.g. learning theories and practices) be considered when designing and implementing Augmented Reality in Saudi universities? Below, please indicate the reason(s) for your response.

____

Q29 Do you think that Augmented Reality technology can support pedagogical practice and theories in higher education?

____

Q30 Readiness or willingness theme

Willingness is an influential factor in the integration of Augmented Reality into teaching and learning methods. Do you think this factor is an important consideration when implementing Augmented Reality in Saudi universities?
Below, please indicate the reason(s) for your response.

____

Q32 Please rate the importance of the readiness or willingness factor.

○ Unimportant (1)

○ (2)

○ (3)

○ (4)

○ Important (5)

Q33 In your opinion, from the perspective of students and academic staff, to what extent is the willingness to adopt Augmented Reality in Saudi universities an important factor?

____

____

Q34 Augmented reality usability and design theme

Usability and design factors are crucial considerations prior to the adoption of Augmented Reality in higher education.
How important is it that the usability and design of Augmented Reality be added to the model for Saudi universities?

- ◯ Unimportant (1)
- ◯ (2)
- ◯ (3)
- ◯ (4)
- ◯ Important (10)

Below, please indicate the reason(s) for your response.

____

____

Q36 Do you believe that Augmented Reality applications are easy to use? Below, please indicate the reason(s) for your response.

____

____

Q38 Do you think Augmented Reality applications are easy to evaluate in education?
Below, please indicate the reason(s) for your response.

____

____

Q40 Do you think that lecturers and teachers will find it easy to design the content of Augmented Reality material? Below, please indicate the reason(s) for your response.

____

____

Q42 Do you believe that using Augmented Reality applications in higher education is enjoyable?

____

Q43 Do you think lecturers and students in Saudi universities will accept Augmented Reality technology in the teaching and learning process? Below, please indicate the reason(s) for your response.

____

Q45 Support and maintenance theme

Having a support and maintenance procedure in place when implementing Augmented Reality in higher education is a crucial factor to be considered. How important is it to add the support and maintenance factors to the model for Saudi universities?
Below, please indicate the reason(s) for your response.

____

____

Q47 How important is the financial support from the government to the incorporation of Augmented Reality in Saudi universities?

Q48 How important is it to have adequate equipment like hardware, software, and connectivity to the integration of Augmented Reality in Saudi university courses?

Q49 How important is technical support to the integration of Augmented Reality in higher education?

Q50 How important is the testing of an Augmented Reality system prior to its adoption by Saudi universities?

Q51 How important is it to offer training on the use and design of Augmented Reality prior to its adoption by Saudi universities?

Q52 Do you think the assessment and evaluation of the impact of Augmented Reality for teaching and learning are important in order to retain Augmented Reality in Saudi universities? Below, please indicate the reason(s) for your response.

____

____

Q54 Effective and cognitive factors

When implementing a new technology such as Augmented Reality in the education context, from your experience: How important is it to consider **students' emotional responses** (e.g. frustration, confusion, attraction, and enjoyment) to Augmented Reality in order to encourage its acceptance by students? Below, please indicate the reason(s) for your response.

____

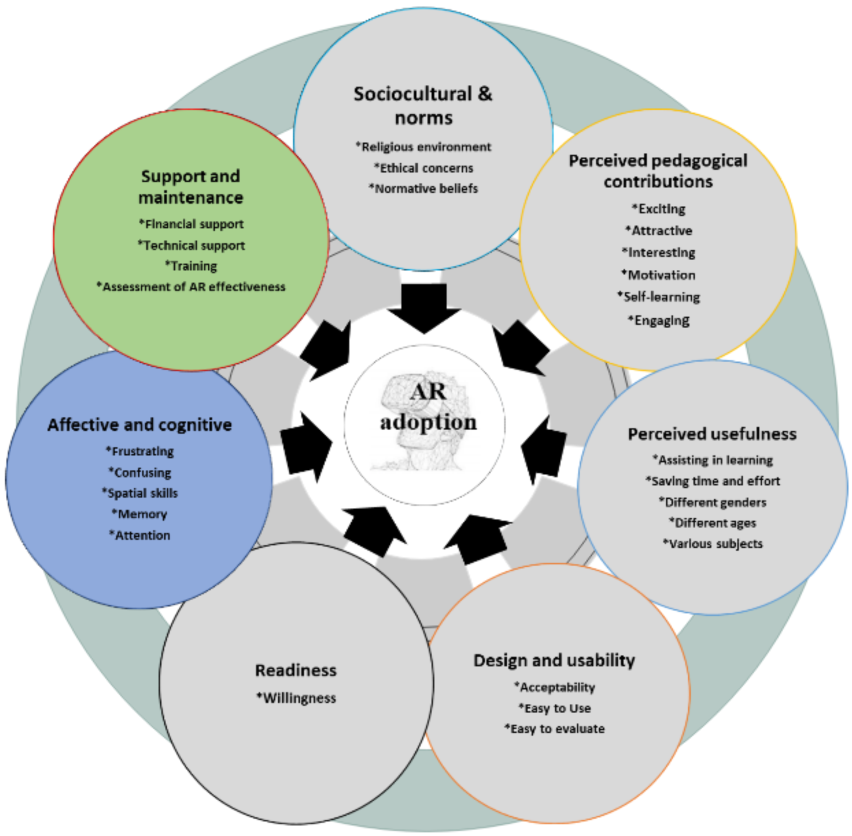
____

Q56 How important is to consider **students' cognitive response** (e.g. attention, memory, spatial skills, complexity) to Augmented Reality in order to encourage its acceptance by students?
Below, please indicate the reason(s) for your response.

____

____

Augmented Reality framework for Saudi Arabia Universities



Q59 Based on our interview, what do you think about the AR model for SA? Do we need to add new factors to the model or delete any factors from the developed model?

____

____

Q60 Why are these specific factors essential? (Factors that you have added or deleted)

____

____

Q61 Based on your experience, what are the factors you consider more appropriate than the ones which are specified in the above model? Below, please indicate the factors and explain their importance.

____

____

Q62 How would you evaluate the overall set of factors for the integration of Augmented Reality in Saudi universities?

◯ Effective (1)

◯ Moderately effective (2)

◯ Ineffective (3)

Below, please indicate the reason(s) for your response.

____

____