A FRAMEWORK FOR THE ADOPTION OF MOBILE AUGMENTED REALITY IN UNIVERSITY LEARNING
CASE STUDY: ISLAMIC UNIVERSITY IN UGANDA

A Post Graduate Dissertation presented to the Faculty of Science in Partial fulfillment of the requirements for the award of the Degree of MSc. Information Communication Technology Management, Policy and Architectural Design

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Dedication

This work is dedicated to my mother Nampala Aminah for her support towards completion of this course, my husband and the children and all colleagues in the Academic struggle.

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To have been able to complete this dissertation, quite a good number of people have participated and therefore deserve my due acknowledgement.

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List of abbreviations

AR	Augmented Reality
ICT	Information Communication Technology
IUIU	Islamic University In Uganda
LAN	Local area Network
LMS	Learning management systems
MAR	Mobile Augmented Reality
PDA	Personal Digital Assistant
PC	Personal computer
SAQ	Self-administered questionnaires
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptable model
VLEs	Virtual Learning Environments
UK	United Kingdom

List of Figures

Figure **Page**

List of tables

Table **Page**

TABLE OF CONTENTS

ABSTRACT

The purpose of the study was to develop a framework for Adoption of Mobile Augmented Reality(MAR) in learning in resource limited environments.

People are trying to understand how the mobile devices will help in attaining better education. In most recent years, due to increasing need for effective knowledge communication, new technologies have emerged. Critical of those is augmented reality (AR) that involves the overlay of computer graphics. AR allows for combining or supplementing real world objects with virtual objects or superimposed information. As a result virtual objects seem to coexist in the same spacewith the real world (Shneiderman, 2010.).

Whereas mobile augmented reality is a promising platform for learning, it is at the same time an immature technology. This immaturity is not only tagged to the technology capability but also training and policy implementation. To address these issues involved, this study suggests a framework that can be used to guide the education stakeholders. The framework is based on a case study Islamic University In Uganda (IUIU).

In this study Information that was analyzed using SPSS software and discussed was supported by views, theories and findings from previous related research to obtain the requirements of the framework. This Framework is structured into three namely; Significant issues, limited resource environment (training, policy, infrastructure and maturity) and Effective intergration MAR with existing learning systems. Each of these components has various attributes that need to be emphasized on if the University is to successfully implement MAR in teaching and learning as illustrated in the Framework. All these were guided by the objectives of this study as presented in chapter 1 of this dissertation. This study employed quantitative method of collecting data using self-administered questionnaires. These questionnaires also collected qualitative information of the respondents like that of experts on e-learning and learning technologies about certain variables but this was coded and analyzed as discrete information.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter explores concepts of mobile augmented reality leading to a framework that helps in its adoption in learning. The chapter presents the problem and the objectives that were used to solve that problem. These objectives were attained using guiding questions that guided the information gathering from the field. The chapter also presents background on which the whole research is anchored. It presents the historical, conceptual and contextual view of MAR in learning. MAR adoption is considered having three critical issues that play an important role (Alsaadat, 2017). These are technological; given that mobile learning is enabled by technology, so the kinds of technologies both hardware and software, their challenges, procedures and applicability form the investigative section in this research. Secondly, pedagogical issues related to how and when to use MAR in teaching students in different courses (Jamali, S.S., 2017). And lastly the learning issues pertaining the student culture, beliefs, abilities and aspirations. Investigating these three critical issues formed a good input to the framework for adoption of MAR in learning with a bias in resource limited environments. In the next section, the background on MAR in learning is provided. This chapter points to the some gaps and concepts that lead to solutions for effective adoption of MAR in learning.

1.2 BACKGROUND

Mobile learning, a form of learning that happens when mediated through a mobile device (Winters, 2007), has established the legitimacy of 'nomadic' learners (Danaher et al., 2009) a reason it has been described as an emergent paradigm in a state of intense development' (Herrington and Herrington, 2007). It combines two very promising areas – mobile computing and e-learning. M-learning has been considered as the future of learning or as an integral part of any other form of educational process in the future. As 'm-learning is quite a new domain there is a lot of work and research that is going on. People are trying to understand how the mobile devices will help in attaining better education (Parsons, D., 2017). In most recent years, due to increasing need for effective knowledge communication, new technologies have emerged. Critical of those is augmented reality (AR) that involves the overlay of computer graphics. AR allows for combining or supplementing real world objects with virtual objects or superimposed information. As a result

virtual objects seem to coexist in the same space with the real world (Krevelen and Poelman, 2010). However, AR is not restricted only to the sense of sight; it can be applied to all senses such as hearing, touch and smell (Krevelen and Poelman, 2010). Simply put, AR allows for combining virtual content with the real world seamlessly (Billinghurst et al., 2008). One of the applications of this phenomenon is in mobile learning- a union of mobile computing technologies and e-learning.

This type of environment enables the learners to access the learning materials from anywhere at any time hence Mobile Augmented learning (MAR). Mobile AR allows us to devise and design innovative learning scenarios in real world settings. This innovation is being catalyzed by the increasing pervasiveness of smart phones and it is set to become a ubiquitous commodity for mobile learning. However, with this ubiquitous availability of MAR, the state of current research leading to effective use of MAR for Learning is still in its infancy (Mardis, 2015) the research in this field should continue and should be addressed to discover the affordances and characteristics of MAR in education that differentiate this technology from others. So far, there is a lack of review studies with focus on helping users conceptualize the design components, requirements, and challenges involving MAR experiences (Hargreaves *et.al,* 2018). In addition, investigating concepts about uses, advantages, limitations, effectiveness, challenges and features of augmented reality in educational settings is significant to attain effective learning for nomadic learners giving rise to personalization for promoting an inclusive learning using AR as a growing area of interest among modern researchers.

In its inception, mobile learning was adopted especially in developed countries like UK by teachers with a use of SMS (short messaging service) as prompts for course requirements, polling classes and pop quizzes (AlMarwani, 2016).

Several researchers believe that AR is not yet well used in new mobile devices like Android based devices, iPad and iPhone. However because most of the current applications include entertainment

, gaming and education used this technology, most already believe that these are “amazing apps” (Liestol, 2015).

Today, AR technology is growing and has been adopted in various fields such as telecommunication and business. Recently, many mobile platforms exist that may support AR, such as personal digital assistants (PDAs), tablet PCs and mobile phones. However, more needs to be done to stimulate the adoption of MAR in teaching paradigm of the current

generation (Carmigniani, et al. 2011). Augmented reality and mobile computing is currently identified as a promising technology since there is an increasing number of devices with the capability of running several of mobile augmented reality applications which are poised to benefit higher education. These interesting technologies can provide many services available on smart phones making it suitable (West, 2016.) for purposes of learning.

Learning is a contextual process therefore it is a function of the activity and culture in which it occurs. This pedagogical approach is called situated learning (Green, et al., 2017) where the contextual space and place are central. With mobile augmented reality and situated simulations it is possible to support and extend the situatedness of learning in new ways by means of information technologies. The advantage here is it extends to any discipline or subject matter that may benefit from making present what is absent, be it past, current, or future topics. This combination of the real and the virtual (what is simulated) also provides added experience and value since it gives the learner information from multiple sources.

Whereas mobile augmented reality is a promising platform for learning, it is at the same time an immature technology (Yan, 2017.) This immaturity is not only tagged to the technology capability but also the adoption framework issues. Whereas the MAR platform as a mode of communication and meaning-making that is still in its infancy poses a challenge for higher education, it is also an opportunity. With the availability of technology and in its entire innovative splendor, the adoption of MAR is still improving and changing.

The ability of learners to benefit from this wave of innovation is up to higher education leaders and how they manage teaching and learning. The threshold for entering this technology is not insurmountably but rather it can actually relatively become easy once there are clear strategies.

Any University's IT center can be innovative here and develop and adjust the technological means to sound pedagogical ends. The question is whether an institution wishes to do so or not. In ICT and education there is a tendency to buy into the educational solutions offered by most software companies (Reinders, et al., 2017. ICT and learning are much more than software; they also include genres of communication. And these have (almost) always been shaped by the users themselves which include teachers and students in their everyday communication and exchange

of knowledge through seminars, lectures, textbooks, workshops and project and paper presentations.

To explore and shape the pedagogical and expressive forms of emerging digital technology-MAR is the challenge of the present research projects including this study. Despite the fact that with support of mobile phones, mobile learning has already started to play a very important role in e-learning, Uganda, as much of sub-Saharan Africa still lags behind in embracing Mobile augmented reality in learning processes (Yu and Ching, 2015). This is partly attributed to poor technology, poor or no framework or models and physical infrastructure. This forms a foundation of this study leading to developing of a framework for use of mobile augmented reality in learning in resource limited areas like Uganda.

1.3 Problem Statement

Mobile technology is necessary to advance mobile learning. This learning is currently spiced by Augmented Reality (AR) that allows for combining virtual content with the real world seamlessly (Alotaibi, 2017).

AR flourishes depending on the degree of pervasiveness of mobile devices such as mobile phones, cameras, music players and portable computers plus relevant guidelines and principles towards effective use of Mobile Augmented Reality (MAR) in learning which are unfortunately still scarce. Through the works of (Dunleavy, 2014) some principles for augmented reality and mobile learning have emerged but with gaps. Such gaps are related to requirements and experiences that would otherwise enable learners to interact with digital information embedded in the physical environment. This research therefore, was conducted with a focus to reduce these gaps through developing a framework for effective learning using Mobile Augmented Reality technologies within a context of resource limited environment.

1.3 Main objective

This study aimed at developing a framework for Adoption of Mobile Augmented Reality (MAR) in University learning.

1.3.1 Specific Objectives

i. To scrutinize the adoption of Mobile Augmented Reality in learning.
ii. To identify the requirements for improved MAR adoption in learning
iii. To Construct a framework for Mobile Augmented Reality adoption in learning
iv. To validate the developed framework.

1.4 Research Questions

I. How Mobile Augmented Reality is currently applied in learning?
II. What are the requirements of effective Mobile Augmented Reality adoption in learning?
III. How to construct a framework for MAR adoption?
IV. How to validate the developed framework?

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

In this chapter, the researcher explores the concept of Mobile augmented reality in learning highlighting its relevancy, contribution and challenges from literature as a basis to formulate a framework to guide its application in a resource limited environment.

2.1 The Concept of Augmented Reality

Today, the education sector boasts of many different methods or avenues through which learners can be educated and trained in respect to specific information and skills they need. These methods include classroom lectures with textbooks, computers, handheld devices, and other electronic appliances (Kangdon, 2011). The choice of learning innovation is dependent on individual's access to various technologies and the infrastructure environment of the surrounding community available. In a rapidly changing society where there is a great deal of available information and knowledge, adopting and applying information at the right time and right place is needed to guarantee efficiency in both school and business settings. Augmented Reality (AR) is one technology that dramatically shifts the location and timing of learning and training. Augmented Reality (AR) or in other words enhanced reality is one of the emerging technologies which have increasingly gained attention over last few years. It is a technology that allows computer-generated virtual imagery information to be overlaid onto a live direct or indirect real-world environment in real time (Lee, 2012).

The concept of AR refers to combining the real world entities and computer- generated digital information into the user's view of the physical real world in such a way that they appear as one environment. While AR has been successfully implemented in the gaming industry (Kumar et al., 2016), other sectors such as manufacturing, health care, sports and education are exploring the possibility of using AR innovatively.

2.2 The Basic Characteristics of Augmented Reality

Augmented reality integrates the synthetic sensory information into the user's perception of the real world (Ware, 2012). The target of augmented reality system is to integrate the interactive real world with interactive computer-generated world, in such a way that they appear to be an environment. Augmented reality has two characteristics: (Zheng, 2015) the notion that video environment in digital space just is the real environment; technically, through the seamless integration of image and three- dimensional geometric model to achieve virtual-real fusion. Augmented reality technology is mainly composed of the following aspects.

Display system

Display system mainly provides the acquisition and display capability of intelligent terminal, including display screen, camera, is an important device for enhancing the applications of augmented reality. The current display screen of smart terminal is more than 3.5- inch, color and resolution of display screen increase gradually (Zheng, 2015). Camera Resolution usually reaches one million levels to ten million levels; you can shoot high-definition images.

Interactive system

Interactive system is the primary means to influence the experience of augmented reality. Currently, smart phones use touch screen interaction, voice interaction and other interactions, to have a great change on human -machine relationship, the interactive reaction can be carried out via multi -channel with the virtual information generated by computer, allowing users go into the scene more naturally, with more fresh sense of the experience (Tindall and Seo, 2016)

Communication system

Wireless communication technology and Internet technology are mobile services supporting technology. In some applications of augmented reality, large amounts of data is stored through remote server, some of the data processing must be done by a remote server (Dinh et al., 2013). 3G and other wireless communications technology enhance the development of augmented reality's applications by providing network bandwidth and other supports.

Three dimensional graphics rendering

The algorithm of modeling and rendering three dimensional graphics superimposes three dimensional objects which can enhance the display in a real environment, to help users understand the environment.

Target recognition

This refers to fine a given target object in the relevant scene, and mark it. Augmented reality needs to implement real-time object recognition in complex moving scenes, such as feature extraction and recognition of complex scenes using multi aspects such as color, texture and contour.

2.3 Augmented reality in Education

Today, the education sector boasts of many different methods or avenues through which learners can be educated and trained in respect to specific information and skills they need. These methods include classroom lectures with textbooks, computers, handheld devices, and other electronic appliances (Kangdon, 2011).

The choice of learning innovation is dependent on individual's access to various technologies and the infrastructure environment of the surrounding community available. In a rapidly changing society where there is a great deal of available information and knowledge, adopting and applying information at the right time and right place is needed to guarantee efficiency in both school and business settings. Augmented Reality (AR) is one technology that dramatically shifts the location and timing of learning and training.

Augmented Reality (AR) or in other words enhanced reality is one of the emerging technologies which have increasingly gained attention over last few years. It is a technology that allows computer-generated virtual imagery information to be overlaid onto a live direct or indirect real-world environment in real time (Duh and Billinghurst, 2008). When students and teachers are faced with not a flat or pure three- dimensional space, but a learning environment that integrated by virtual objects and real scene, just like augmented reality, the traditional means of interaction may not adapt. But it also provides more space can be explored, such as how to establish course content by situated cognition theory and learning activities theory in the environment of virtual-real fusion, how to create teaching activities, how the communication between learners be more direct, how to build users' learning experience model and interactive behavior model, all these problems wait the developers and users of augmented reality learning environment to explore.

ABI Research made prediction that by 2014 the revenue of AR mobile market will reach $350 M(Chi et al., 2013). Looking at those numbers uncovers that MAR has a positive impact on learning value perception.

According to (Salinas, 2017), their studies on SMART (SysteM of Augmented Reality for Teaching) reported positive impact of Augmented Reality (AR) applications in learning environments in terms of capturing the attention of the learners, encouraging active contribution, student's learning attitudes, interaction and motivation.

2.3.1 Integration with existing learning management systems

Augmented reality environment must be able to share data with existing information systems, or have some kind of association, in order to be accepted by mainstream educators (Schmalstieg et al., 2011). But to put together two distinct environments, we need more people to use it and the intensive study of how this integration environment to enhance teaching effectiveness, so as to comply with existing and new teaching methods Integration with intelligent technology. The current augmented reality learning environment is only able to create three- dimensional graphics and simple interaction, but learning is a very complex activity process, the ideal augmented reality learning environment should be able to mimic the experience, methods and behavior of teaching instructors, and have more friendly interactive methods (Yuen et al., 2011). Until the emergence of new technological innovations the most common teaching method has been the direct communication between students and teachers usually taking place in the classroom. Although current teaching methods work successfully, most higher education institutions are interested in introducing more productive methods for improving the learning experience and increasing the level of understanding of the students. The emergence of new technological innovations in computing as provided the potential for improving them. For instance, the web-based Virtual Learning Environments (VLEs) that many universities have adopted for aiding the teaching process are characteristic for this (Weller, 2007). A recent study has shown that virtual learning applications can provide the tools to allow users to learn in a quick and happy mode by playing in virtual environments

In particular, the introduction of Information and Communication Technologies (ICT) not only in schools but also in higher education institutions has been welcomed by students and educators worldwide (Livingstone, 2012). Most multimedia applications available for higher education purposes utilize teaching material in a number of formats including text, images, video, animations and sound. These tools usually build upon traditional teaching methods, making the subject matter more interesting and challenging for both the students and the lecturer. Consequently, any future systems and techniques must take into consideration the current trends and needs of the higher education sector which is adopting these new technologies fast.

(Mar et al. 2012) suggest the use of AR has satisfied students' needs in supporting learning and motivational elements in both formal and informal exploratory activities subsequently, Many universities are eager in exploiting new visualization methods to improve the current teaching models (Liestøl, 2011) and one of the most promising technologies that currently exist is augmented reality (AR). In technical terms, AR is an amalgamation of computer graphics, vision and multimedia, which enhance the user's perception of the real world through the addition of virtual information. In AR the real environment must be harmonized (and synchronized) with the virtual in position and context to provide an understandable and meaningful view. To improve student retention and participation in computing disciplines, learning should be more fun (Siemens, 2013) therefore, educators not only need to recognize a unique learning style but also recognize and adopt MAR technologies correctly for the successful development of effective learning and teaching strategies that will in turn bring the following potential benefits.

•Multi-modal visualization of difficult theoretical concepts
•Practical exploration of the theory through tangible examples
•Natural interaction with multimedia representations of teaching material
• Effective collaboration and discussion amongst the participants

2.3.2 Characteristics of an Ideal educational AR system

(Carmigniani, *et al.*, 2011)

•be simple and robust
•provide the learner with clear and concise information
•enable the educator to input information in a simple and effective manner
•enable easy interaction between learners and educators

•make complex procedures transparent to the learners and educators
•be cost effective and easily extensible

2.4 Benefits of AR in Education

Augmented Reality (AR) is currently considered to be one of the key emerging technologies in education, providing new opportunities for teaching and learning, by allowing a virtual world of digital content to be overlaid and mixed into the learner's perceptions of the real world, thus creating an enhanced and augmented reality (Dunleavy and Dede, 2014). Whereas Traditional methods of presenting teaching material are affordable, it can satisfy student demands only to a certain degree. For example, when teaching computer graphics it is really difficult for students to understand the concept of 3D if only traditional methods (i.e. PowerPoint presentations, websites, etc) are used. A cost effective AR audio-visual presentation of virtual multimedia content can be utilized to exploit the potential benefits of using alternative technologies to improve current teaching methods. Using virtual multimedia content, students can see real-life 3D examples of the principles they are studying as well as interact with them in a natural way.

The majority of educational AR applications operate in indoor environments and therefore Registration between the real and virtual information becomes one of the most important issues of AR and can be achieved either with the use of sensor devices or via computer vision techniques (Liarokapis and Anderson, 2010).Although, both techniques have proven advantages and disadvantages it seems that vision systems work much better in indoor environments while sensor-based systems are preferred for urban outdoor environments. A vision-based AR learning solution has been adopted since the target environment is the class- room and it is much easier to control environmental parameters such as the lighting conditions. In addition, the cost of most of the technologies used in vision-based AR systems can be afforded by most higher education institutions – the cost of the system used here is a standard computer with a web camera.

Although the introduction of MAR started in 1968, it evolved in 1993 with the invention of smartphones when development of wearable technology and motion graphics (Arth et al., 2015). In recent years, mobile Augmented Reality (MAR) has become very popular. Using Augmented Reality (AR) in the learning environment includes many advantages enabling designing and

developing effective learning solutions to improve school standards. Researchers think that MAR can allow improving student's perceptions, knowledge, and interaction with the real-world and it can also lead to improved productivity in real-world tasks for student centered learning (Shneiderman, 2010).

Eye-Catching Presentations

By integrating augmented reality into lectures, the attention of the student is captured giving a lecturer/teacher an opportunity to have the student's undivided attention.

For instance, a teacher can use dentistry integrated augment into his lessons to show 3D models of teeth and how the human jaw works.

Interactive Lessons

Students are able to access models on their own devices via Augment's app. By viewing augmented models, the students can gain a better understanding of the concepts they are studying. This is a fun way to engage students and reinforce concepts they've seen during class lectures.

Higher Retention

With a simple scan, students can access augmented models representing anything from a part of the human anatomy to a famous monument to a molecule (Panksepp, 2004). Also, students can access websites directly from the Augment's app. For example after scanning a photo linked with a 3D model of the Eiffel tower and viewing the augmented Eiffel tower, students can go directly to a web page with more information on the famous monument. This experience creates a complete learning cycle. With this arrangement, students retain more knowledge for a longer period.

Foster Intellectual Curiosity

Incorporating Augment into lessons makes students excited about learning. Born in the digital era, students will be continuously stimulated with augmented reality. They can be excited by new ideas and think critically about the world around them (Beatty, 2013). Therefore, introducing augmented reality to students enables them to discover unknown passions and inspire their future endeavors.

Portable and Less Expensive Learning Materials

Prototypes, physical models, and detailed illustrations and posters are all extremely expensive. More often than not, schools do not have enough money to buy all the supplementary learning materials they would like. Further, these learning materials get worn down, lose their relevance, and get misplaced over time (Rennie & Morrison, 2013).

With Augment, you do not have to invest in physical materials. Students can access models from any device at any time. Whether they are at home or in the classroom, students can study and interact with the course materials.

2.4.1 Augmented reality in Mobile learning

The use of AR in education, and particularly in mobile learning, is still in its infancy and it remains to be seen how useful it will be in creating effective learning experiences (FitzGerald, 2013). AR can be used successfully for situated and constructivist learning, particular when collaboration and student inquiry are key. AR has also been shown to support informal learning experiences. (Cook, 2010) also examined the use of AR to support collaborative problem solving. He suggests that mobile devices and their surrounding physical environment enable learners to generate their own contexts for development, which can be interpreted or assisted through AR.

Although much interesting work has been done in the area of virtual worlds and education; however we are more concerned with how learning takes place in an augmented world. focus on the use of augmented reality for mobile learning is still required, in all senses of the word ‘mobile’,

Where the learner is not constrained to a desktop computer at a fixed location and the learning itself may be dynamic and across contexts.

Mobile AR adds new elements. Importantly, it fosters the mobility of users, increases the physical places where learning can occur, serves as bridge between these places, and enables connections between formal and informal learning. MAR is poised to diligently serve as a mechanism for more personal or individual experiences with AR than are possible with a large static display. Since Spatial mobility is a powerful component (Cowan & Butler, 2013), once it is combined with temporal mobility it will allow learners to take advantage of AR resources at times and places convenient and relevant to them. Mobile AR enables the integration of experience and meaning within specific contexts (Munnerley et al., 2012).

In the past, technological limitations often confined AR devices and their users to a fixed location. Nevertheless, developers have always aimed to make AR portable.

2.4.2 THEORIES ABOUT LEARNING IN AUGMENTED REALITIES

In order to gain insights into the learning affordances of mobile AR, there is need to compare it with mobile learning and pedagogical theories relating to non-augmented, otherwise normal reality.

A focus on learning through interaction with 'reality' provides a direction into situated theories of learning and a careful attention to context (Yoon et al., 2012). Developers, educators and e-learning designers often lack clarity regarding the impact that a student's situation has on their interpretation of e-learning. Human consciousness is associated with the use of tools and artefacts (Vygotsky,1986), which mediate contact with the world. These tools produce quantitative improvements in terms of the speed and efficiency of human development; they also produce qualitative transformation because mediated contact with the world provides humans with the means to have full control to manage and organize their behavior rather than be buffeted by external stimuli (Vygotsky, 1978). Considering issues of space and time in any learning process are of essence (Bowker, 2000) since one's 'reality' is continually mediated and reinterpreted by one's practices and meaning-making exercises. Although At a first glance, the shift from low-tech to mobile-tech and now to AR may seem merely quantitative: augmenting/adding to reality has always been a part of outdoor education, whether it is through informative signposts at a site or straightforward on-site tuition by a teacher or parent. Human beings change their perspectives,

understanding and meaning-making of reality by augmenting it with additional information. Technology for example, merely offers systems and resources that can enhance a situated (FitzGerald et al., 2013) through the mechanisms of augmenting the available realities more effectively.

Embodied cognition can also provide a complementary framework, because AR affects the ways of interaction with the physical world. The bodily experiences – including cultural, contextual and social factors – which we engage with when we use AR help us to construct meanings from our reality.

The goal of the learner is to align multiple perspectives to form a coherent understanding. It is easy to see how this applies to augmented reality, particularly to the provision of information to learners in a range of multimodal formats. Variation theory proposes that the process of experiencing something different and being mindful of this difference – i.e. an awareness of a variation – facilitates learning (Akerlind, 2008). This implies that augmented reality certainly helps learners perceive their surroundings in a diversity of ways. They may need to be supported to recognize these differences and to integrate these cognitive dissonances effectively. An alternative interpretation however is that, because reality is subjective and perception is linked to cognition, the understanding of objects and places changes once we have interacted with them (Jones, 2011).

2.4.3 Adopting MAR in learning and Training

According to (Chang, 2010), several researchers have suggested that students and trainees can strengthen their motivation for learning and enhance their educational realism-based practices with virtual and augmented reality. In spite of a great amount of research during the last two decades, adopting MAR in learning and training is still quite challenging because of issues with its integration (Cox, 2013) with traditional learning methods, costs for the development and maintenance of the MAR system, and general resistance to new technologies. Now that AR, however, has the promise to attract and inspire learners with exploring and controlling materials from a diversity of different perspectives that have not been taken into consideration in real life, AR in education and training is believed to have a more streamlined approach that has wider user adoption than ever before due to the improvement in computer and information technology. Even though many MAR applications have been developed for educational and training purposes since the advent of MAR in the late 1960s (Kerawalla, 2006), its potential and pragmatic employment

has just begun to be explored and utilized in real life. AR has the potential to have learners more engaged and motivated in discovering resources and applying them to the real world from a variety of diverse perspectives that have never been implemented in the real world.

2.5 Examples of Augmented reality applications

The following MAR applications discussed below are some of the existing and well known applications in the education sector. It is prudent to note that sectors (Webb, 2012) like commerce, tourism, technology etc have got respective applications. The interest here, however, is on the education sector MAR applications since it's the subject this research focuses about. Augmented reality is a trend that is worth following as new apps and technologies are developed to make learning innovative, interesting and fun.

Google Sky Map

This is an augmented reality app which makes learning about astronomy interesting and fun. Instead of looking at descriptions of constellations in a book and then attempting to identify them in the sky, you can use Google Sky Map to directly identify stars and constellations using the camera on your Smartphone (Goel and Bhardawaj,2014).

FETCH Lunch Rush

Recently released by PBS KIDS, FETCH! Lunch Rush is an augmented reality app to teach math skills to elementary students through the use of visualization. Designed in 3-D, the app uses your Smartphone camera to place graphics on your camera over real-world surroundings. The app then teaches elementary students to add and subtract using real-world scenarios which allow for visualization while solving math problems.

GeoGoggle

GeoGoggle is a great helper when it comes to acquiring geography skills and judging distances to specific destinations. Students can learn geographical measurement such as latitude and longitude by applying GeoGoggle to real-world surroundings.

ZooBurst

This is a nifty augmented reality app to help elementary level students learn through visual imaging. With this app, students get to interact and become a part of a story. Zoo Burst allows you to engage in digital storytelling by designing storybooks complete with 3-D characters.

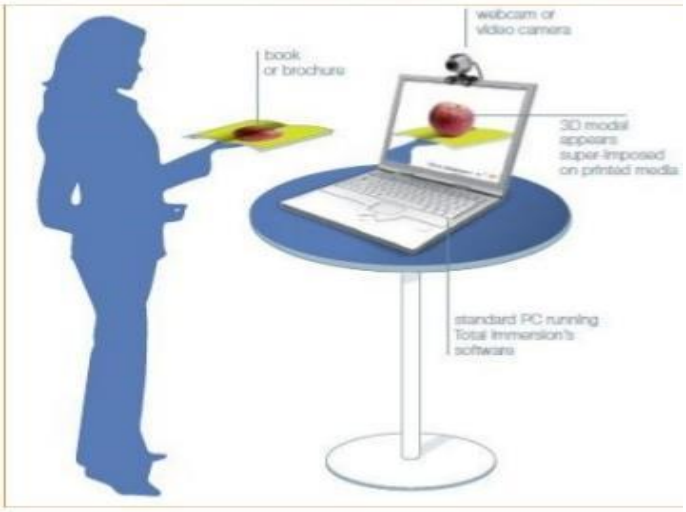
Acrossair

Acrossair is a browser which can be used in real-world surroundings and in the classroom for learning and discussion. The browser can carry apps that push the boundaries of the uses of augmented reality. You can find locations near you and share your locations with friends. Students can also create interactive classroom projects, and participate in interactive photo walls displaying wiki and multimedia on a classroom topic.

ARToolKit application which allowed developers to use many different languages like flash or Silverlight, Android , DraiodAR, beyondAR, GeoA (Tan & Lee, 2018).

How Typical Augmented Reality System works

A standard virtual reality system seeks to completely immerse the user in a computer generated environment. This environment is maintained by the system in a frame of reference registered with the computer graphic system that creates the rendering of the virtual world. For this immersion to be effective the ego centered frame of reference maintained by the user's body and brain must be registered with the virtual world reference. This requires that motions or changes made by the user will result in the appropriate changes in the perceived virtual world. Because the user is looking at a virtual world there is no natural connection between these two reference frames and a connection must be created (Azuma 2003). An augmented reality system could be considered the ultimate immersive system. The user cannot become more immersed in the real world. The task is to now register the virtual frame of reference with what the user is seeing.



(Jaseem, 2014: Downloaded at https://www.Slide share.net/jaseembhutto/augmented-reality-by- jaseem-bhutto on 04 July, 2017)

Brief Procedure

- The webcam connected to the computer is capturing video in the traditional manner and when the user holds the 'marker' in front of the web cam it sees the marker, captures the information/ partner encoded in it and sends this information to the computer.
- The computer recognizes the information and overlays the marker with an image. To the viewer, it appears as though the image has materialized by magic.
- The computer can track the size and movement of the image. This means if user moves the marker closer to the webcam the image will get bigger. If user tilts the marker to the left, image will tilt to the left.
- This process is similar to sports telecasts seen on television, such as swimming events, where a line is dynamically added across the lanes to indicate the virtual position of the current record holder as a race proceeds.

(Jaseem, 2014): Downloaded at https://www.slideshare.net/jaseembhutto/augmented-reality- by-jaseem-bhutto on 04 July, 2017).

Tips for better adoption of AR in education

Consider the application: AR works especially well where it is difficult to expose students to real-life environments. One example where this has been used to good effect is cARe, a project run by City University London to provide simulated clinical training to nurses, allowing them to enact scenarios based on patient care that mirrors the real world (TE-LIEN, 2014).

Simplify the subject material: If you work in a maths or science discipline you might not think AR is applicable to you, but actually it's an excellent conduit for conveying abstract concepts. Using interactive visual simulations can better articulate complex themes that have no frame of reference in users' minds. If you're trying to communicate a topic that might be considered difficult, AR can be an effective route in (Steiner, G., 2013).

Visualise your users: Think about who will be using the app and what learning environments they are used to. AR can be beneficial in very visual subjects, such as architecture, construction and engineering. Students are more likely to embrace technology when it feels natural and transparent, and is aligned to what they are used to doing (Schumacher, 2001).

Test your ideas: Initial feedback might have told you that your student group is receptive to working with AR, but if you fail to consult them during the development cycle you could deliver something that is a long way removed from what they were expecting (Wasko,2013). Whatever you are creating, it is hugely important to test with a pilot group, ensuring the students find the solution useful and effective (and hopefully enjoyable too).

2.6 Issues with AR

There are three issues associated with augmented reality. They are; Technological, pedagogical, and learning issues.

2.6.1 Technological issues

As mentioned previously, one type of AR technologies includes a head-mounted display and/or an additional backpack with computer equipment. The cumbersome and expensive design could cause problems such as discomfort and poor depth perception (Kerawalla et al., 2006). To avoid these problems, current development of AR systems adopts portable technologies that are less

obtrusive and enhance a sense of immersion and presence. Yet, these systems integrate several hardware and software devices and lead to issues like interfacing between multiple devices (Klopfer&Squire, 2008) and stability of the devices (Dunleavyetal., 2009 ; Squire&Jan, 2007).Without well-design interfaces or protocols to guide students 'actions, students could have difficulties in interpreting the clues in the devices and the real-world environment, recognizing the information flow from one device to another, and navigating between fantasy and reality (Squire & Jan, 2007). Additionally, the more the devices used, the greater the risk of device failure. How to maintain high stability of multiple devices becomes critical. In (Dunleavy et al., 2009), GPS errors caused students' frustration and were identified by teachers as a highly problematic issue. Fortunately, the issues of device integration and stability could be solved by the recent rapid advancement in portal and wireless technologies. In addition to more than a dozen of software applications, a tablet PC or a smart phone could include a built-in video camera, GPS, wireless receiver, faster processor, and large hard-drive memory. It can be expected that the portable devices in AR systems will be more and more integrated and reliable when running simulations, games, videos, and GPS applications. Another issue is regarding a tradeoff in technology design between location dependency and independency (Klopfer & Sheldon, 2010). While location- specific technologies contextualize students' learning, provide a connection to a particular location, and help students give new meaning to their familiar locations, location-independent design has advantages in portability and flexibility that does not require teachers and students to be present in specific locations and could save great cost of transportation.

To balance the two approaches, educators and designers may consider a design that not only connects to real-world locations but also includes important features that can be commonly found in other locations (Klopfer & Sheldon, 2010). Time Lab 2100 is an example that integrates portability with location specificity and provides generic real-world locations (e.g., a school and a bus stop) so students could find local substitutes for their learning needs.

2.6.2 Pedagogical issues

There are also pedagogical issues that need to be taken into consideration when AR systems are implemented in classrooms. First, like many educational innovations in the past, the use of AR in classrooms could encounter constraints from schools and resistances among teachers (Harwood, 2010).

The learning activities associated with AR usually involve innovative approaches such as participatory simulations and studio based pedagogy. The nature of these instructional approaches however is quite different from the teacher-centered, delivery-based focus in conventional teaching methods (Kerawalla et al., 2006;Mitchell, 2011;Squire & Jan, 2007). Institutional constraints such as covering a certain amount of content within a given time frame also cause difficulties in implementing innovations (Kerawalla et al., 2006). Thus, there may be a gap between the teaching and learning methods currently used in classrooms and the students-centered and exploratory nature of learning engendered by AR systems. Designers of AR learning environments need to realize the gap and provide possible support to help teachers and students bridge it. A second issue involves instructional design. In the design of learning activities and AR systems, how should the information be distributed and flowed between two realities and among different devices? As Klopfer and Squire (2008) indicated, " how to balance competing drives for individuality with distribution and decentralized information flows with guided educational activities may be tensions central to the platform"(p. 205). A set of design guidelines based on learning theories (e.g., distributed cognition and situated learning) and empirical evidence would be useful for educators and designers to resolve this tension. Another pedagogical issue is regarding the in flexibility of the content in AR systems (Kerawalla et al., 2006).

In some AR systems, the content and the teaching sequence are fixed; teachers are not able to make changes to accommodate students' needs or to accomplish instructional objectives. This issue could be resolved by the use of authoring tools (Bergig, Hagbi, El-Sana, & Billinghurst, 2009), which allow teachers and students to revise and create AR activities and applications (Klopfer & Squire, 2008).

2.6.3 Learning issues

There are also challenges related to learners and their learning processes. In an AR learning environment, students could be cognitively overloaded by the large amount of information they

encounter, the multiple technological devices they are required to use, and the complex tasks they have to accomplish. That is, students need to be multitasking in AR environments.

(Dunleavy et al. 2009) reported that students often felt overwhelmed and confused when they were engaged in a multi-user AR simulation because they had to deal with unfamiliar technologies as well as complex tasks.

Additionally, the tasks in AR environments may require students to apply and synthesize multiple complex skills in spatial navigation, collaboration, problem solving, technology manipulation, and mathematical estimation (Dunleavy et al., 2009).

Previous research indicated that one reason for students ' learning challenges in AR environments lies in a lack of these essential skills (Kerawalla et al. 2006;Klopfer & Squire, 2008; Squire & Jan, 2007). Particularly for younger learners and novices at conducting open-ended investigations, additional Scaffolding and support would be necessary to help them generate an appropriate plan of action, search for possible solutions to their problem, and interpret clues provided by the technological devices and embedded in the real-world environment (Klopfer and Squire, 2008). Furthermore, AR provides a situation where reality and fantasy are blended but this mixed reality could cause students' confusions. In Klopfer's (2008) study, some students" lose sight of where the game ends and reality begins "(p. 100). Even though such confusion signals the authenticity of an AR system, losing track of the real environment may not be productive for learning and could result in a threat to students' physical safety (Dunleavy et al. 2009).

2.7 Existing frameworks of Augmented Reality in learning

2.7.1 MARE Framework

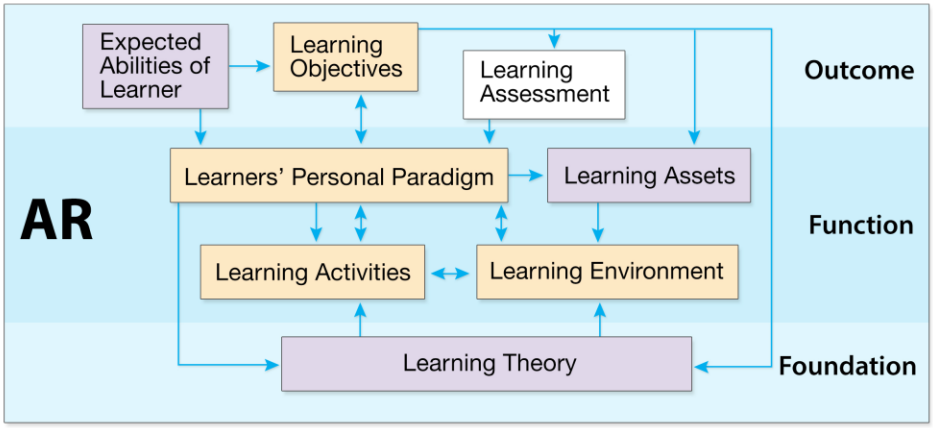


Figure 2. 1MARE framework

According to this model, the learner is central to the instructional design guided by this MARE framework. These concepts include learning theories, objectives, assessment, activities, environment, materials, and the personal paradigm. They have been mapped to three main layers of MARE which are foundation, outcomes, and function. This framework was developed to guide the adoption of AR in health care education.

The three main layers of the framework provide the hierarchical structure for the content objects. The design order started with defining learning objectives in the outcome layer. The foundation was developed through examining theories that support the MARE framework and its associated AR characteristics. Designing the function level was guided by the learning theories, in an effort to achieve the outcomes. The framework design was an iterative process; the AR function layer is the design object, while the foundation and outcome layers provide support to achieve the design aim. The factors within a layer (colored orange and purple) should be considered while designing each layer. The four key elements shown in orange are highlighted in the framework. The purple factors help to support each layer, as needed. One-way arrows pointing to a concept are influenced by their starting ideas. The two-way arrows align with the concepts, as both the source and the target of relationships.

Foundation Layer

The foundation provides the reasons why MARE is useful for health care education and considers the first question regarding which learning theories are suitable. Different learning theories provide different views on learning. Learning theory is the foundation for devising learning activities, organizing study content and materials, and establishing learning environments. Guided by suitable learning theory, AR can perform optimally in health care education.

Function Layer

Function shows how health care learning could be achieved with MARE. The function depends upon the learners' personal paradigms, and provides support for the outcome and foundation levels. Learning requires suitable material and activities in an appropriate environment. These learning materials and activities should be selected and developed by considering the learning objectives and the learners' paradigm, along with the AR learning environment. The choice of activities and environments should be grounded in learning theory from the foundation level and the characteristics of AR.

Outcome Layer

The outcome helps to understand which abilities health care learners may achieve through MARE and informs how to design the functional level of MARE. Professional certification requirements and the learner's paradigm include pre-knowledge and influence the learning objectives. Meanwhile, the learning assessment standards, as part of the outcome level, should be ascertained according to the specific learning objectives.

Gaps in the framework

It was developed to help AR adoption in health care hence giving a gap to improve it to fit in the educationsector.

The primary goal of the framework was to guide the development of AR educational apps rather than AR use in teaching and learning (Zhu et.al., 2015). This framework is used for guiding the design, development, and application of mobile AR for medical education in the health care setting as compared to teaching and learning in the mainstream education. The framework was driven by only one theory which is theory of situated learning with an understanding of the characteristics of AR and specific medical disciplines toward helping medical education improve professional development from knowledge to practice. Other theories include, situated learning, experiential learning, and transformative learning (Kaufman et.al., 2010)

In addition, since the data sensitivity in health care is different from that in the main stream education, frameworks developed to improve AR usage in healthcare would not automatically apply in education.

Secondly, the usability of the equipment is more required in the education as compared to health care since the main users are students who may be in most cases novice users as compared to medical workers in the health care.

The MARE framework was developed based on the research conducted in resource environments (developed countries) and d thus its improvement to suite the resource limited environments is desirable. Resource limited environments is characterized by semi-skilled human resource, in adequate technological infrastructure and inappropriate legal and policy framework which would accelerate the usage of new technologies like augmented reality (Kalsi et al., 2009). All these later on influence the social environment which is a key driver in the technology uptake.

Strengths of the framework

The framework puts emphasis on the learner who is central in this study. Therefore, this concept will be adopted for the proposed framework.

The adoption of the learning theories is another strength for this framework thus its inclusion in the proposed framework.

The framework was an output of a research influenced by learning theory to guide the design or application of AR for health care education. As compared to the traditional learning strategy, "see one, do one, and teach one," was used to apply the new technology.

Difference between health and mainstream education.

The real health education environments are the immediate context in which a connection is needed between learning and practice. The real clinical environment is the anchor and scaffold upon which learners are encouraged to learn. The real clinical environment includes physical environments and social environments. According to (Zhu et.al., 2015), The content in physical environments, such as patients and their disease, microbiological samples, documentation and clinical notes, medical equipment, drugs, and consequences of bacterial

resistance, can be the anchor to trigger a learning activity, which then aims to fulfill a learning outcome within the appropriate therapeutic stage. The similarity between health education and mainstream education is that they both share the same social environment. The social environment (ie, local culture and customs, organizational norms, and policy) shapes the content and forms of learning, which should be more instrumental or communicative (Kiely,2005).

2.7.2 AR ACCEPTANCE MODEL

The framework (figure 1.2) was developed as a result of a study aimed to contribute to the gap in the AR acceptance literature by the identification of external dimensions. The identification of external dimensions of AR acceptance is particularly important as this research area is still new and received little attention by previous scholars. Therefore, (Leue et al. 2014) called for a qualitative investigation of potential external dimensions within the AR acceptance context. According to the proposed model, information quality, system quality, costs of use, recommendations, personal innovativeness, risk and facilitating conditions influence the perceived ease of use and perceived usefulness of AR applications. In addition, the AR acceptance model, similar to the original TAM, suggests that perceived ease of use has a positive effect on perceived usefulness as well as the attitude towards using. Furthermore, it is suggested that perceived usefulness has a positive effect towards attitude, which in turn affects the intention to use and consequently the actual usage behaviour.

The model suggests that tourists' mobile AR acceptance may be dependent on seven external dimensions such as information and system quality, costs of use, recommendations and personal innovativeness, risk as well as facilitating conditions (Leue et al. 2014). In addition, it provides context-specific external variables of technology acceptance as demanded by (Ayeh et al., 2013). This means that information and system quality are considered important in terms of mobile AR acceptance within the tourism context.

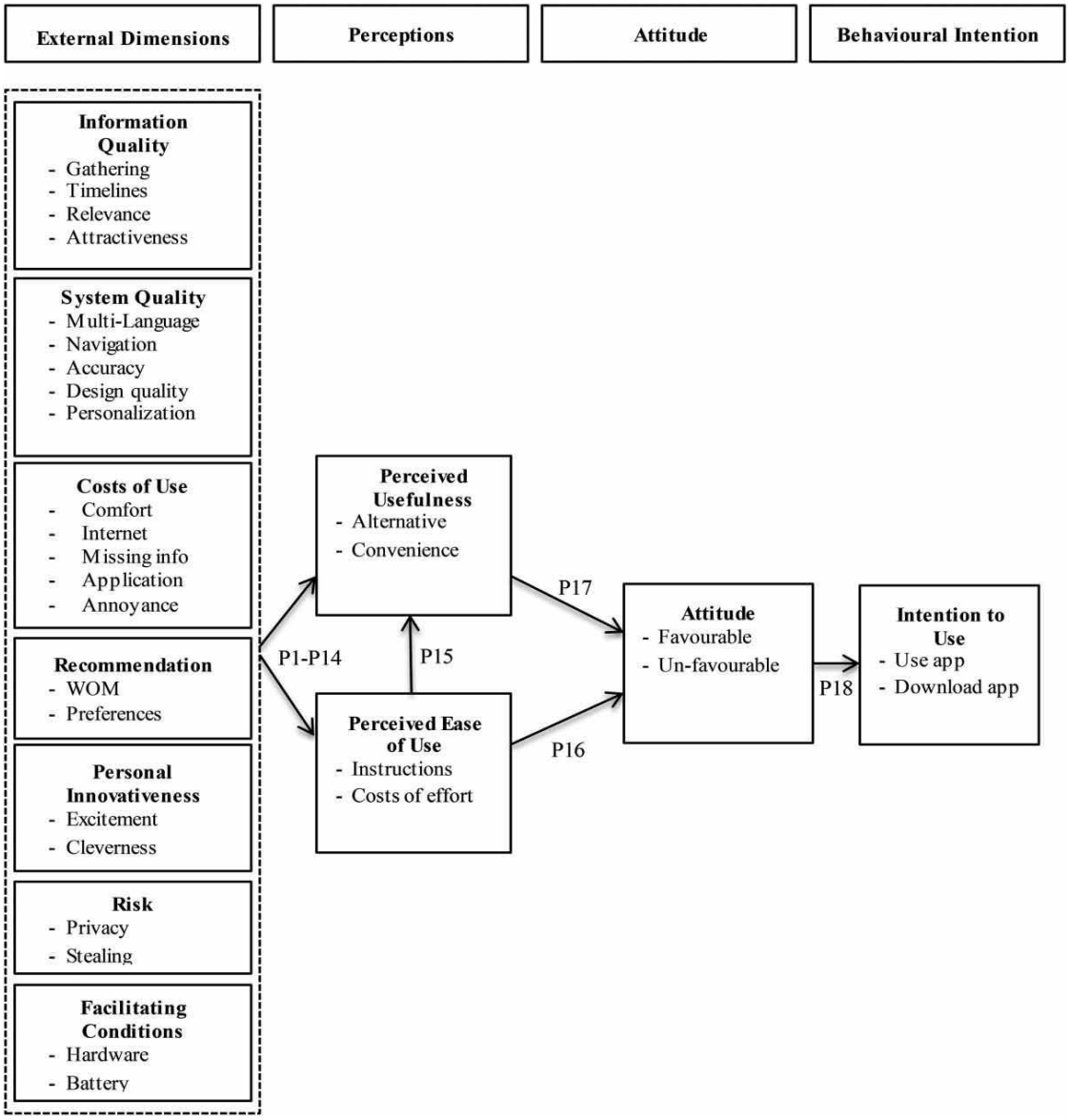


Figure 2.2 AR acceptable model

Gaps in the framework

The framework focused on acceptance of AR as a technology but not particular to adoption since acceptance involves both adoption and Use.

The framework concentrated on the AR applications but not the entire AR system which includes both the peripheral hardware devices like camera and smart phones and applications

The framework did not offer special attention to the mobile augmented reality which is the gist of this research but rather just AR. The study that gave rise to this framework was not necessarily conducted in resource limited environments.

All the above gaps form as basis for using this framework as a benchmark to the adoption framework of MAR in learning in resource limited environment.

Strengths

The framework has been tested to point out issues to do with acceptance and adoption of any form of technology.

Concepts like perceived ease of use and perceived usefulness are fundamental in the development of technology adoption frameworks.

2.8 Methods that have been used in validating the quality frameworks

Validation can be regarded as a process by which a judgment is made as to whether a tool is (Lee et al., 2006) fit for purpose.

To validate quality frameworks, methods mentioned can apply (Inglis, 2008).

Reviewing the research literature related to effectiveness in online learning. The research literature on online learning should, in theory, provide a strong foundation upon which to base the development of a quality framework and strong validation of the suitability of the framework once it has been constructed. However, the adequacy of this approach as a method of validation depends on which literature has been used and the way in which it has been used to underpin the decisions that have been made. The problem with this approach is that as this area of research has only recently opened up the depth and quality of the research across the field is rather uneven. While it is appropriate to draw on the research literature, the literature may not provide sufficient guidance on this point.

Seeking input from an expert panel; Use of an expert panel offers a way of bringing a high level of expertise to bear on the process. It is a way of reducing the level of bias that can creep in when one relies on one expert alone. The views of different members of the panel balance out. However, use of an expert panel does not of itself provide any assurance that the judgments made will be the best informed. The consensus that is reached can be very much a function of the consensus-building process that is used. Factors that can impact the process include: the composition of the panel, the way in which the panel was briefed, whether the panel was offered the opportunity to review its decisions. The larger the panel, the more reliable will be the judgements that are made.

Undertaking empirical research; Empirical research was aimed at identifying the variables upon which students base their perceptions of quality. Such research can be carried out in the context in which a framework is being used with the types of learners with whom processes based on the quality framework are to be applied is likely to provide the strongest confirmation of fitness for purpose. Such research is likely to be based on some form of clustering protocol such and factor analysis or principal component analysis.

Undertaking survey research; what is being referred to as survey research in this context is research aimed at gathering attitudinal data from staff of institutions involved in aspects of course design, development and/or delivery. In this case of this form of validation, the scope of the validation will be determined by the range and types of institutions sampled, the number and roles of the individuals surveyed, and the extent of the information gathered.

Conducting pilot projects; Piloting the use of a quality framework involves application of the framework on a limited basis with concurrent monitoring of the results. Piloting generally involves a limited number of instances and the generalisability of the findings of a pilot project may consequently be quite limited.

Drawing on case studies. Use of case studies for validation is similar to the conduct of pilot studies with the exception that the case study does not involve de novo trialing of the quality Framework. This form of validation may be used when a quality framework is derived from existing practice rather than being created for the purpose of establishing a new set of practices.

2.9 Potential of AR

(Anderson,2015) AR offers several special pedagogical opportunities:
(1) Mobility
(2) Visualization (which may be manipulated by the viewer) (3) Alternative perspectives
(4) Comparison/contrast of multiple perspectives
(5) Integration of multiple perspectives

Current research into adoption of AR in education has mainly focused on 1 and 2 That is, the provision of flexible learning opportunities through delivery of information to handheld devices, and the visualization of information or perspectives that might otherwise not be available to students, either because of physical or financial constraints (Lee, 2012).

It is now time to focus on 3 and 5, but to do so with consideration of the overarching purpose, that is to create an increasingly student centered learning experience in which the student connects, integrates, constructs and deconstructs his or her own meanings from his or her own experiences. Some recent developments in higher education illustrate precisely why such an awareness/emphasis is essential if the potential of AR is not to be become just another passing fad (Steele *et.al.* 2012).

A good example comes from the increased focus on interactivity, particularly in traditionally content-focused disciplines such as the hard sciences. Without an understanding of the purpose of interactivity and curriculum design, efforts at increasing interactivity run the risk of being limited in their impact on student learning. Thus simulations are seen as enhancing student learning despite evidence that, at least in some cases, they have simply provided an animated visual that may be rote-learned instead of an equation. Where individual teachers incorporate their uses of technology within a curriculum design approach informed by a belief in a particular theory of learning, great things may be achieved, but such development will inevitably be patchy, unpredictable and ad hoc. It's thus important to have a framework guiding use of AR in education. If developments are presented within a broader framework of how learning happens, they are much more likely to be exploited in ways that encourages deep learning.

There is need to focus on the learner; on what is happening when a more sophisticated understanding is developed, and what ingredients are required to help that happen.

Augmented reality technologies can be used to augment reality to promote reflection, integration, a questioning attitude, critical thinking and well-established learning goals in much traditional pedagogy. AR can provide additional depth and richness, or prompt learning characteristic of the more sophisticated outcomes (Fink, 2013)

- Providing additional information on an object, such as relating to its origins the processes used to create it, or its impact on the environment: a mobile device could itself be labelled with information on the different elements and compounds used to make its components, together with their origins and histories.

- Providing access to physically inaccessible views of an object, whether closer or more distant, from above or below, or from any other perspective that has the potential to render the object unrecognisable or strange. Radical perspective changes could be used to challenge students' senses of familiar objects, and to encourage them to reflect on how their ''usual'' view may not be that shared by others.
- Augmenting senses, such as object visualization, possibly using infra-red or ultra-violet, or creating a journey through subsequent layers to the microscopic level. By providing new ways of seeing not available to un augmented human senses, we can challenge students to reflect on the constraints on their own ways of seeing, and on how those constraints affect their interpretations of what they observe.

- Combining and comparing multiple views, simultaneously layering into a new dimension of change. By creating a third dimension spanning variation in parameters such as time, or visible frequencies, we hope to encourage awareness of similarities and differences.

- confronting the alien or unexpected by exploring the reactions and responses, opinions and beliefs of others
- Creating a shared narrative of learning or a pedagogical autobiography by explicit reflection on how being confronted with the memories, associations, beliefs and understandings of others transform the student's own individual understanding of a particular event, phenomenon or concept.

2.10 Conclusion

The use of AR has revolutionized how many things are done, where the evolution of ideas that were only imagined, has made it possible for these imaginations to seem real (Peterson, 2015). In education, AR has enabled students and teachers to understand biological features for example body internals are displayed and can be maneuvered in 3D (Lidsay, 2015). The hindrances that come about due to complexity of issues are made simple through the use of AR. This literature has considered issues related to technological, learning and pedagogical as fundamental in the adoption of the mobile augmented reality. In addition, factors as presented in the AR acceptance model are also considered.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter covers the research design, population, sampling methods, sampling size and procedure, data collection instruments and how the data was analyzed.

3.1 Research Design

This study focused on the use of augmented reality for effective learning. The researcher preferred the deductive research approach (Gill and Johnson 2010) because it can be based on the general idea to reach at the specific situation. Descriptive research is designed to provide a picture of a situation as it naturally happens (Burns and Grove 2003). It may be used to justify current practice and make judgment and also to develop theories. In this study, descriptive research was be used to obtain a picture of students and staff's opinions of learning and teaching using augmented reality respectively. In this regard, this study employed Case study and survey methods to obtain requirements from the respondents. Case study was used to obtain the impact of technological, pedagogical and learning issues on the students and staff of IUIU so as to empirically explore and investigate their contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships based on any mix of quantitative and qualitative approaches. Survey method is well known for emphasis on quantitative data obtained from variety of types including but not limited to mail, phone, face to face and online.

3.1.1 Research Methods

The study adopted the mixed research approach. Mixed methods approach is one in which the researcher tends to base knowledge claims on pragmatic grounds (e.g., consequence- oriented, problem-centered, and pluralistic). Simultaneous or sequential data was collected using both quantitative and qualitative tools. Numeric information by use of instruments like self-administered questionnaires as well as text and opinioned information by use of interview was conducted to get relevant information from a total of 220 students and 80 staff at IUIU. The researcher employed this method to verify and gain a better understanding of the requirements from the field. Some Data collected using questionnaires acted as a basis to obtain the opinions

and suggestions of respondents about using Augmented Reality applications and systems. This method indeed helped to answer the ‘why’ and ‘how’ questions in this study.

3.1.2 Research approach

The research population, sample, sampling size, sampling process and procedure and the setting were discussed.

3.1.3 Research population

The study population included; All registered students, and Lecturers at IUIU. At the time of the study, there were 3000 students, 103 Lecturers.

3.1.5 Sampling size and sampling procedure

Sample size influences the importance or quality of the study with guidelines in determining sample size in quantitave research (Holloway and Wheeler, 2002) unlike qualitative.

The sample size for this study was determined by reviewing literature of similar study as one of the approaches to determine same sample size.

In this study, a total of 300 respondents engaged as source of primary information. Of these, (80) were Lecturers while the rest (220) were students. The researcher worked with management to identify students and staff based on their involvement in the use mobile augmented reality and related technologies.

3.2 Sampling Process

Purposive sampling is a method of sampling where the researcher deliberately chooses who to include in the study based on their ability to provide necessary data (Parahoo (1997:232). The rationale for choosing this approach was that the researcher was seeking knowledge about the students and staff’s opinion and views learning using augmented reality applications and systems which the respondents would provide by virtue of their experience or inexperience with AR. In this study only eligible students and lecturers were purposively chosen to participate in this study.

3.2.1 Sampling procedure

Sampling of the participants was done as follows:

- The researcher sought the assistance of the ICT officer of faculty of science regarding identification of potential participants.
- Possible participants were selected after the researcher pre-selected participants according to the criteria under research population.
- The research project was explained to the prospective participants who were on the short-list and they were asked personally if they wanted to take part in the research. So those who accepted were included in the sample.

3.3 Data collection instrument

3.3.1 Questionnaires

The researcher employed self administered questionnaire to obtain requirements from the respondents in appendix 1. This questionnaire was categorized into sections; AR Issues related to technological, pedagogical and learning and factors that affect diffusion of technology such as Information quality, cost of use, personal innovativeness, Systems quality, recommendations, facilitating conditions, Associated Risks. Other information to be obtained from respondents using SAQ is demographic information such as age, gender, level of education and experiences.

3.3.2 Observation

Using the observation, the researcher was able to identify the existing infrastructure that can facilitate the adoption of MAR.

3.4 Data analysis

The Data analysis was uni-variant. It involved obtaining frequencies and percentages (descriptive statistics) and generation of graphical information on elements of the framework arising from the respondents backed by literature.

The requirements obtained from the reviewed literature were used to guide the formation of questionnaires in a bid to understand the factors for adoption of MAR in a resource limited environments. The information obtained from the field was analyzed using graphs and frequency tables so as to achieve objective one and two. In order to achieve the third objective, the existing frameworks were analyzed component by component by taking note of the strengths and

weaknesses which acted as an input to the proposed framework. In the third objective, responses from the participants during the validation process were analyzed to determine the relevance of the proposed framework in adopting MAR in learning in resource limited environment.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

4.0 Introduction

This chapter presents findings and an analysis of results on the study conducted about the adoption of Mobile augmented reality (MAR). The goal of study was to develop a framework that supports this adoption process. Data from the respondents was collected using self-administered questionnaires (SAQ) and observation. SAQs were analyzed by the researcher to obtain the requirements for the framework as a major output for this study.

This chapter begins by presenting the background demographical information about the respondents who participated in the study as a key informant for this study.

4.1 Background Information of Respondents

4.1.1 Distribution of Respondents by Gender

This table shows that were more males (65.6%) as compared to their female counterparts (34.4%)

Table 4. 1: Distribution of Respondents by Gender.

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	189	65.6	63.0	65.6
Female	99	34.4	33.0	100
Total	288	100.0	100.0	

4.1.2 Distribution of Respondents by Age

Respondents were distributed according to age groups as shown in the table 4.2 below.

Table 4. 2: Distribution of Respondents by Age

	Frequency	Percent	Valid Percent	Cumulative Percent
18-30 years	127	42.3	42.3	42.3
31-40 years	108	36.0	36.0	78.3
40-above	65	21.7	21.7	100.0
Total	300	100.0	100.0	

Most of the respondents (42.3%) fall in the age range of 18-30 and (36%) are in the range of 31-40 while (21.7%) were above 40 years.

4.1.3 Distribution of Respondents by Designation

Table 4. 3: Distribution of Respondents by Designation

Designation	Frequency	Percent	Valid Percent	Cumulative Percent
Senior lecturer	32	10.7	10.7	10.7
Lecturer	21	7.0	7.0	17.7
Asst_Lecturer	25	8.3	8.3	26.0
Professor	2	0.7	0.7	26.7
student	220	73.3	73.3	100.0
Total	**300**	**100.0**	**100.0**	

4.2 Existing Infrastructure

Using the observation, the researcher identified the existing infrastructure that can facilitate the adoption of MAR. This is presented in the table 4.4 below.

Table 4. 4: Existing ICT supporting Equipment at IUIU

No.	Category	Sub Category	What is Existing
1	Networked	Internet/intranets	WiFi (Wireless access points) 40 computers connected to internet Via DSL modem in the staff room
2		LAN/MAN	90 Computers connected through Ethernet protocol
3		Telephony	Existing limited intercom access
4	Power source	Primary	Hydroelectric power supply
5		Secondary	standby generator
6	Enabling equipment	Hardware	Over30 Projectors No smart board Over 130 PCs- desktops in good working condition 24 regularly faulty Scarce Individualised portable gadgets like iPad/POD
7		Software	Windows 7 operating system plus Microsoft packages Installed on all computers

			A good Number of these computers have Linux Operating systems Plus a host of different application programmes
6	Procedures/Policy	MAR Policy/Guidelines	Not clearly documented

4.2.1 Respondents' views about existing supportive infrastructure

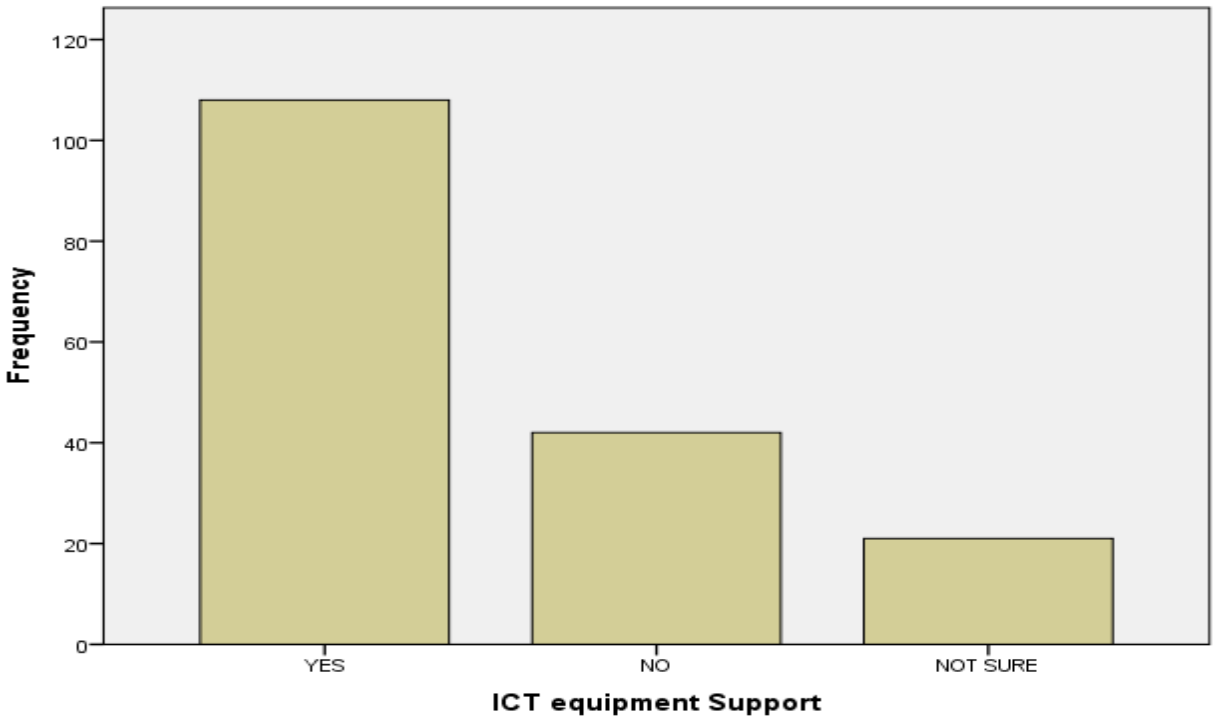


Figure 4.1: Existing ICT equipment/ Infrastructure for the Use of MAR

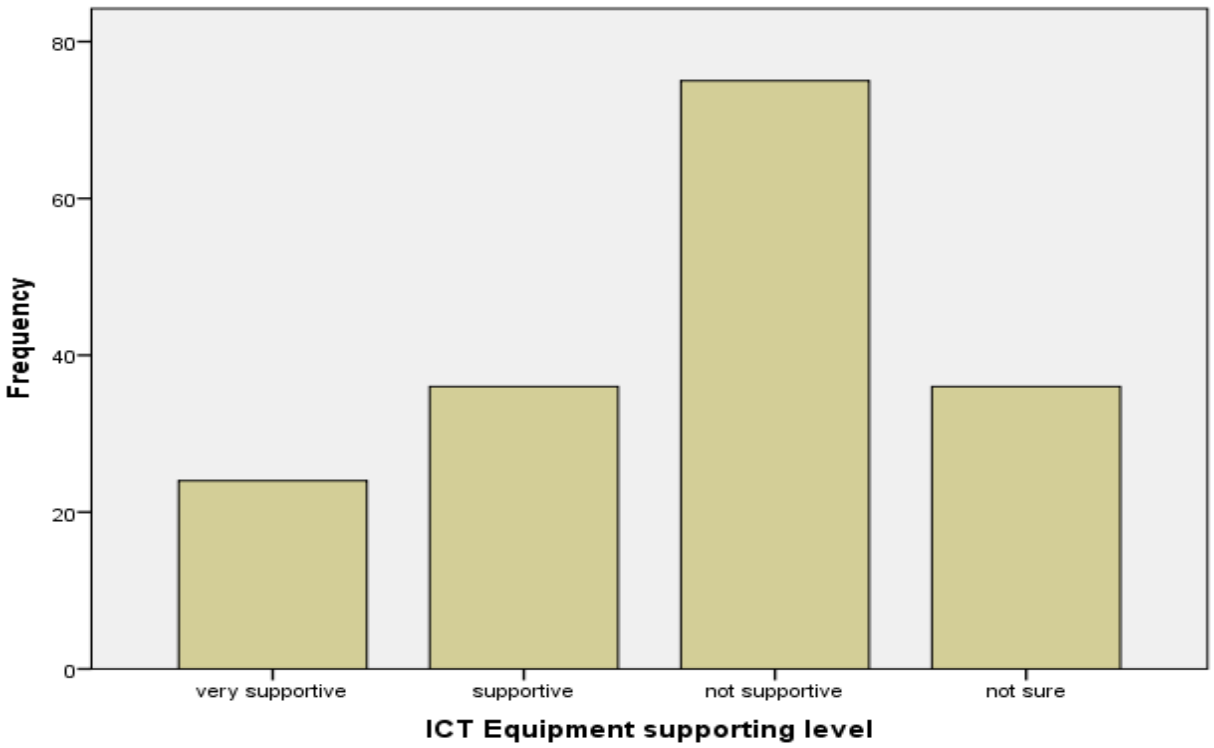


Figure 4.2 Level of Support of Existing Infrastructure to the Use of MAR

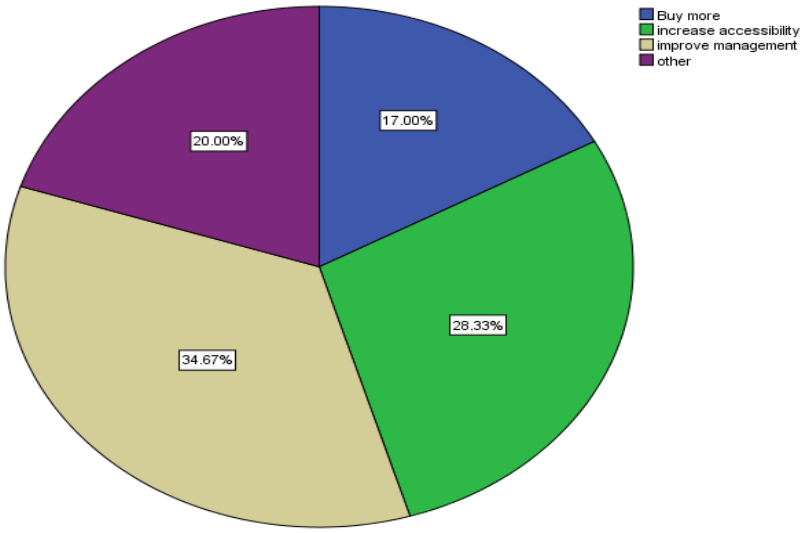


Figure 4.3 Suggestion to Improve Existing ICT Infrastructure

From the figure 4.1 above, most of the respondents (as represented by the highest bar) agree that there equipment that support MAR are available. However, as indicated in Figure 4.2, most

of the respondents agree that the existing infrastructure is not very supportive for the use of MAR in teaching/learning. The respondents suggested improvement in management (34.67%), increase in accessibility (28.33%) and buying more equipment (17%) as shown by Figure 4.3.

This explains the high levels of respondents indicating that existing ICT equipment's is thus not supportive in MAR adoption. This is in agreement with (Höllerer & Feiner, 2004) who points out that in most developing countries, political and economic situations accelerate the inaduacy of advanced technology infrastructure.

Remedies to this problem according to the research, is presented in the pie chart below with 38.7% suggesting that more equipment that is affordable should be adopted and 54.9% proposing streamlining management of ICT equipment while 6.3 were not sure of what to do to avert the challenge. This is in line with works of (Lee, 2012) that emphasize the need to create more affordable equipment that can be easily used by low income education environments.

4.3 Policy on Adoption of MAR

4.3.1 Availability of MAR Policy

Table 4. 5 whether or not the institution has MAR policy

	Frequency	Percent	Valid Percent	Cumulative Percent
yes	97	32.3	32.3	32.3
No	161	53.7	53.7	86.0
not sure	42	14.0	14.0	100.0
Total	300	100.0	100.0	

From table 4.5 above, most of the respondents agree that there is no MAR policy (53.7%) , (32.3%) said that it is there and 14% were not sure if it exists or not

4.3.2 Policy Importance in Implementing MAR

Table 4. 6 Policy Importance in Implementing MAR

	Frequency	Percent	Valid Percent	Cumulative Percent
very Important	60	20.0	20.0	20.0
important	89	29.7	29.7	49.7
not as important	106	35.3	35.3	85.0
not sure	45	15.0	15.0	100.0
Total	300	100.0	100.0	

The table 4.6 above shows (49.7%) rated MAR policy important to be implemented, (35%) rated it not important and 15% were not sure of its importance.

4.4 Training Staff and Students in the Use of MAR

4.4.1 Percentage of Respondents who were trained

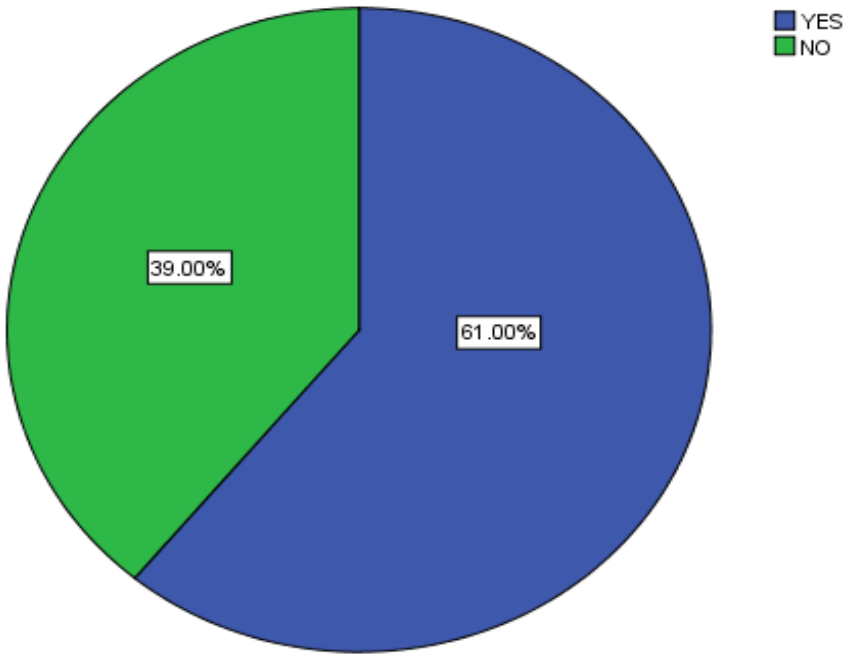


Figure 4. 4 A Pie Chart Showing Respondents who were Trained in the Use of MAR

From the pie chart 4.4 above, 61% were trained and 39% were not trained

4.4.2 Intensity of Training of Respondents

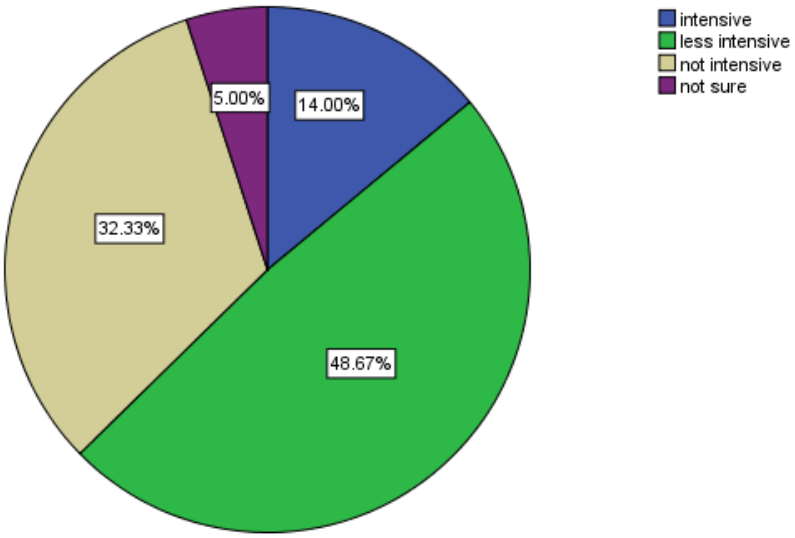


Figure 4.5 A Pie Chart Showing Intensity of Training of Respondents

From the figure 4.5, Yes training was done as illustrated by figure 4.4 but its intensity was rated as less intensive (48.67%), not intensive (32.33%) and only (14%) rated training as intensive.

4.4.3 Frequency of training

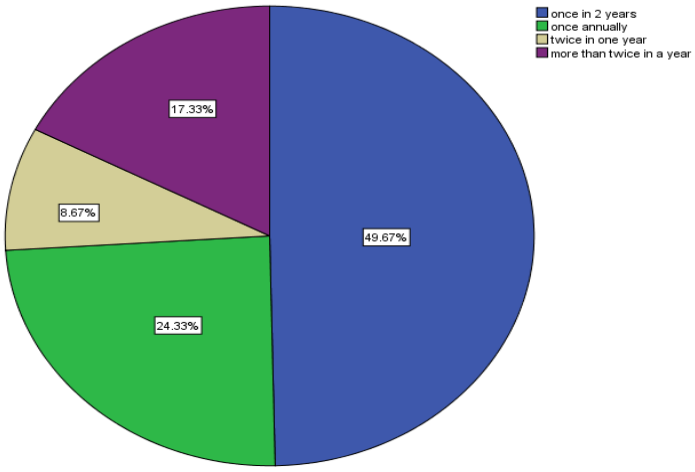


Figure 4.6 A Pie Chart showing frequency of Training of Respondents

Figure 4.6 above shows training done (49.67%) one in two years, (24.33%) once in a year, (17.33%) more than twice a year and (8.67%)twice in a year.

4.4.4 Interest in getting familiar with Use of MAR in teaching and learning

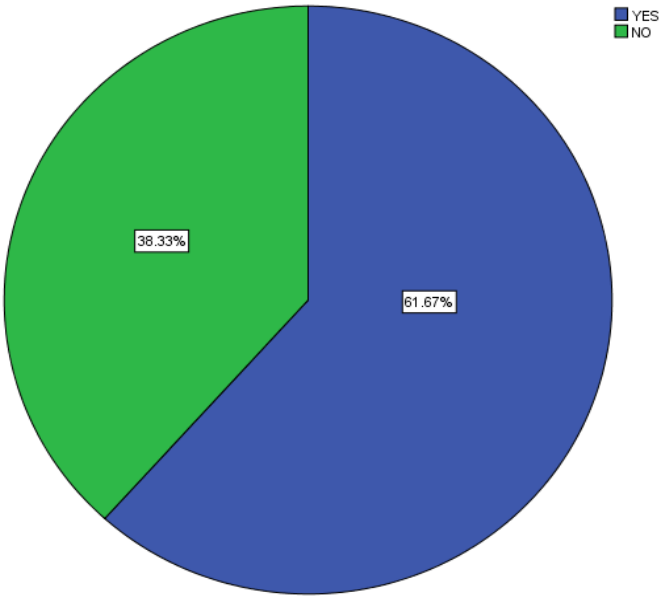


Figure 4. 7 A Pie Chart showing percentage of respondents interested in getting familiar with use of MAR

The Figure 4.7 above illustrates (61.67%) of the respondents being interested in getting familiar with using the MAR in teaching and learning and (38.33%) having no interest.

4.5 Application of MAR in teaching and learning

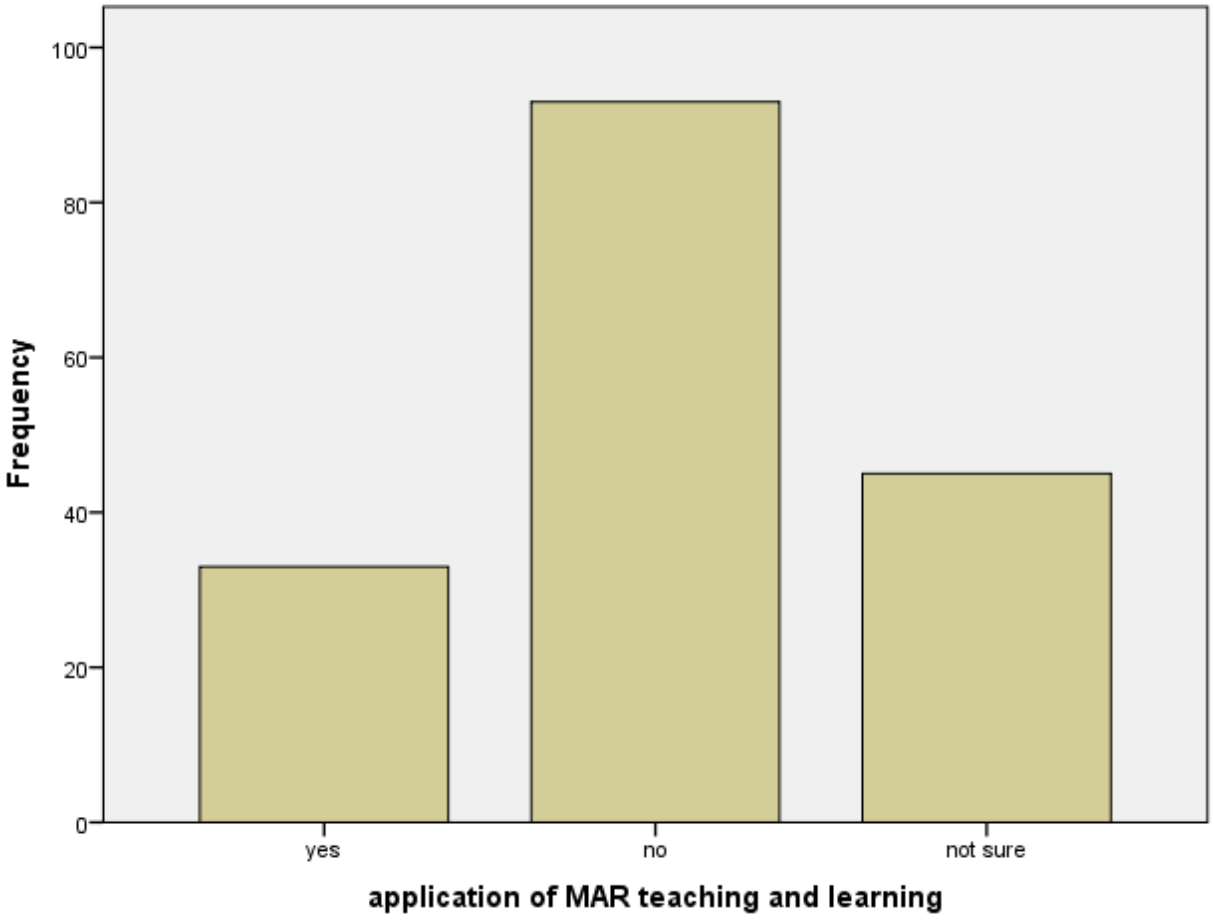


Figure 4. 8 Application of MAR in Teaching and Learning

From the figure 4.8 above, most of the respondents do not apply MAR in teaching and learning (as represented by the highest bar) and very few use it in teaching and learning

Discussion of Results

4.6 Existing ICT Equipment

Because education involves a process of acquiring knowledge, improving ones power to reason and judge different situations (Good, 2003) and generally of preparing oneself or others intellectually for matured life, it needs to be supported by sufficient infrastructure such as ICTs. This therefore, lack of sufficient infrastructure facilities affects the whole teaching and learning process. Today, Classrooms have changed dramatically over the last decade with the advent of new technologies and equipment developed to make teaching and learning more diversified and interactive. These equipment such as computers and projectors and now augmented reality applications such as Google Sky Map, FETCH! Lunch Rush, GeoGoggle, ZooBurst, Acrossair provide for visual aid, greater flexibility for alternative teaching methods, enhanced teacher demonstrations, heightened student awareness and customized curriculum applications(Geddes, 2004). It is therefore imperative to have sufficient and well-functioning of these equipment to adequately support ICT applications which is not the case with the situation at IUIU as evidenced by respondents in figure 4.1. Therefore, in the proposed framework, existence of ICT equipment will be one of the components earmarked to support MAR adoption to support teaching and learning.

4.7 MAR Adoption Policy

According to the results from this research, there is no MAR policy at IUIU as evidenced by the (53.7%) of the respondents (figure 4.5) rejecting knowledge of the policy existence. Since policies are nonexistent, the advancement and promotion of the application of technologies like MAR is lucking and because of this (Anderson, 2007), MAR adoption remains a myth. This MAR adoption policy will be a key component of the proposed framework for adopting MAR in teaching and learning at university.

4.8 TRAINING

From the study conducted at IUIU, Results show that the frequency and intensity of the training in the use of MAR is wanting. 57% say that the training is extremely inadequate as evidenced in the below respectively is lacking. Because the Institute keeps admitting new students on an annual basis and recruits new teaching staff, there is need to perform routine training on how to use MAR technologies with high intensity in terms of the content covered. Training on In-depth navigation of the platform should be done to enable users explore all the features of MAR so as to choose the appropriate ones to adopt in their processes. Because of the centrality of the training (McMillan, 2005) in the adoption of any technology in teaching and learning processes, the proposed framework will include this component plus its integral recommendations on how to do it in terms of frequency, intensity, who to do it etc.

4.9 Summary of requirements from the field study

From the information gathered from the field, the following was found necessary to assist in the adoption of MAR in teaching and learning at University. These requirements are based on the three most drivers of the adoption process. Policy, infrastructure and training

Table 4. 7 Showing the requirements as obtained from the field

No	Item	Requirement	Intervention
1	POLICY	Dedicated Policy for MAR use	Developed by experts
		updating of policies and frameworks	Regular basis
		Publication of procedures and guidelines	Both in print and Electronic
2	Infrastructure	Hardware systems	Install affordable and Usable systems
		Applications Software	Install relevant and affordable Educational AR apps
3	Training	Regularize training Intensify Training Scheduled training	Attract expert trainers Apply knowledge/skills retention
4	(Demographic)	Issues related to · Level Of Education · Age · Gender	Motivation, Mentorship and nondiscrimination principles

4.10 Requirements from Literature

Ensuring choice of applications that are interoperable with LMS and VLE. MAR is suitable for learning if there is the applications are highly interactive (Mehd, 2011) for novice users to easily grasp. This means that both interactivity and interoperability are concepts determining adoption of MAR systems in learning. Research also shows that there need to maintain high stability of multiple devices by application of recent rapid advancement in portal and wireless technologies (Wu et.al, 2013).Use of authoring tools which allow teachers and students to revise and create AR activities and applications (Parker et.al. 2007). Authoring tools tremendously help in getting familiar with MAR applications.

The need of essential skills to students and novice users so that they can be multitasking in AR Environments (Crandall *et.al.* 2005). Because of the influx of applications both mobile and web based, training the users is important to enable them have capacity to switch from one knowledge area to another. This applies also to the devices both mobile and stationary devices are on increase on the market but are quite challenging in terms of application and yet users have interest in using them (Nitika, 2014). This challenge is seen in terms of quality course ware, training logistics, staff turnover, and localization, learning delivery platforms and learning needs of the organization (Holmes & Gardner, 2006). This kind of support helps reduce possible resistance from teachers and students and can also improve buy-in from eve the technologically biased stakeholders (Brosda ,2015). Another element that has been applied to speed the adoption of MAR is devising a set of design guidelines based on learning theories to eliminate tensions from the education stakeholders and regulators through Ensuring well-design interfaces or protocols to guide students ’actions (Munafo, 2016).

Framework Development Process

The process of building this proposed framework was divided into three phases. The first phase began with a review of literature to obtain relevant information about adoption of MAR in learning. This information was obtained in relation to resource limited environments in terms of challenges and possible remedies of MAR adoption in learning. It is worth noting that not all the requirements reflected in the literature were applicable for the case of this study.

The second phase involved selecting some of the salient issues that arose from the field to guide the questionnaires to obtain the opinions and views of those currently involved in the diffusion process of MAR in learning.

The third phase was to select and merge the requirements according to the views of the respondents especially senior and junior lecturers as they were considered as experts in usage of MAR in teaching and responses from students too were not entirely left out as they are key to this research presenting them in the image below.

4.10 Proposed framework for the adoption of mobile augmented reality in teaching and learning at university in resource limited environments.

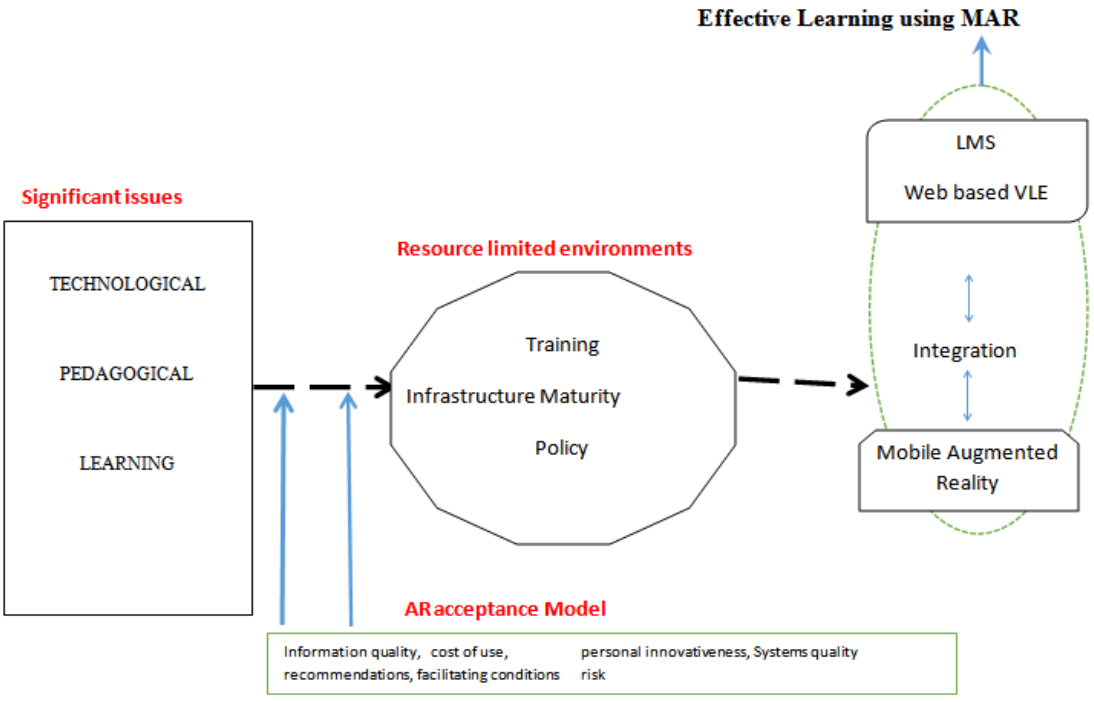


Figure 4. 9 shows the proposed framework

Explanation of the framework

Figure 4.9 above represents a proposed framework for the adoption of Mobile Augmented Reality in teaching and learning at university in resource limited environments.

In this framework there are three sections, each with different limiting factors. i.e. significant issues, AR acceptance Model and those particular to resource limited environments.

Significant Issues

(Bonk and Graham, 2012) points out three core issues of emphasis that play a significant role in determining the rate of adoption of mobile augmented reality. In the case of University education, this framework suggests concerted effort towards adopting portable technologies that are less obtrusive and enhance a sense of immersion and presence. Further it advocates for systems that integrate several hardware and software devices to attain interfacing between multiple devices (Kim and Feamster, 2013). This is because without well-design interfaces or protocols to guide students 'actions, students could have difficulties in interpreting the clues in the devices and the real-world environment, recognizing the information flow from one device to another, and navigating between fantasy and reality (Wu et.al., 2013).

The second, which is pedagogical seeks to create buy in from both lecturers and students who are key stakeholders. This can be achieved by including MAR principles in the study curriculum, creating flexible study content in AR system by use of authoring tools (Mahmoud, 2008).

Thirdly, the learning issue is about regulating the amount of information students encounter, the multiple technological devices they are required to use, and the complex tasks they have to accomplish all these lead to students' cognitively getting overloaded that can result in poor learning (Driscoll et.al., 2005).

The AR Acceptance Model.

The Proposed Framework borrows concepts from the AR acceptance model presented as potential external dimensions such as information quality, system quality, costs of use, recommendations, personal innovativeness, risk and facilitating conditions influence the perceived ease of use and

perceived usefulness of using AR applications (Lee et. al., 2003). Since MAR is much of applications like any other technology, the perceived ease of use and perceived usefulness as discussed by TAM model greatly impacts on the adoption of MAR in teaching and learning (Lee et.al., 2013). Therefore this framework suggests a consideration of these factors in the adoption process of the MAR and all efforts to control them will aid the adoption of MAR.

Justification of borrowed components from other frameworks

- Firstly, all underlying Elements from AR acceptance model are borrowed because the model focuses on web-based learning which is inevitable for the case of learning as observed in the framework regarding MAR integration with LMS and web based VLE.
- Secondly, these elements are crucial factors that influence adoption of any technology as supported by TAM that is, whether students, lecturers, or Universities have purchased and installed Mobile Augmented reality systems and why—than about end-user reactions such as how and why implemented ITs are used.

Resource Limited Environments

This study was done with a case of resource constrained environment, the analysis of the findings obtained from the field at IUIU revealed that training, infrastructure maturity and policy are central and therefore are mediating factors to the adoption of MAR. They greatly affect the integration of MAR with VLE and LMS which are common applications in use today. Therefore management must do what it takes to perform vigorous training for all the users, improve the infrastructure maturity levels and develop and implement relevant policies and procedures to guide the adoption, implementation and use of MAR.

4.11Validation of the Framework

With the aim to validate the proposed framework, the researcher used Expert opinion method to validate the developed framework. This was done with an objective to ascertain the relevancy and applicability of the mobile AR technology adoption in resource limited.

For the purpose of validation and justification of effective use in other universities, gathering lecturers from these universities as experts into the panel was hard due to time issues and other

costs encountered. For flexibility, the framework and Questionnaires (Appendix 2) for validation of MAR proposed framework in teaching and learning in resource limited environments were presented to them. In the questionnaires, each section presented key concepts of the framework. Validation questions were attached in at the end of each key concept and finally general framework validation questions.

Five lecturers from each of the following universities i.e Kyambogo University, Uganda Christian University, Busitema and Ndejje University that are experts in e-learning and technology were given the questionnaires for their input and the results were as follows;

4.11.1Results of Validation process

4.11.1.1 Significant issues concerning MAR Adoption

Table 4. 8 Table showing significant issues

	Agree		Disagree		N	
Item	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Technological	15	75	5	25%	20	100
Paedagogical	19	95	1	5	20	100
Learning	75	15	25%	5	20	100

From table 4.8 above, majority (75%) of the respondents agree that multiple technological devices affects learning of students and 25% disagree. Furthermore, it represents that most of the experts (95%) agree that including MAR principles being included in the curriculum creates flexible use of MAR.

4.11.1.2 MAR resource environment as framework key concept.

Table 4. 9 **showing resource environment for MAR**

	Agree		Disagree		N	
Item	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Training	19	95	1	5	20	100
Infrastructure	17	85	3	15	20	100
Policy	15	75	5	25%	20	100

From the table 4.9 above majority (85%)Agree that training of students and lecturers in the basics of MAR in a resource limited environment is required and a few Disagree.75% agree that the MAR usage policy should be in line with the existing university values and 25% disagree.

4.11.1.3 MAR Intergration with existing management systems as framework key concept.

Table 4. 10 Table showing MAR Intergration with existing learning management systems

	Agree		Disagree		N	
Item	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Intergration	20	100	0	0	20	100

From the table 4.10 all experts (100%) Agree that Mobile Augmented reality environment must be able to share environment with existing information systems is required and none of them disagree.

4.12 Conclusion

This chapter concludes with a framework to facilitate adoption of mobile augmented reality in university learning. Having critically analyzed the existing literature and obtained the fillings, opinions and suggestions from the respondents (experts) who are of well know of MAR, the researcher presents considerations such as consistent training of users, supporting infrastructure; implementation policies and flexible integration of MAR with other existing learning management systems as key contributors to the success or failure of MAR in learning.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1Introduction

This chapter presents a conclusion of the research and points out the recommendations made by the researcher.

5.2 Conclusion

The main purpose of the research was to develop a framework for MAR adoption in learning. Existing studies assert that mobile learning can facilitate a pedagogical shift by encouraging a meaningful two-way, informational flow between teachers and learners, moving away from the old 'banking' method of teaching where knowledge is simply transferred from teacher to student without any space for critical analysis on the part of the learner (Wims& Lawler, 2007;Nawaz &Kundi, 2010c; Kundi& Nawaz, 2010). More particularly, Mobile learning with augmented reality makes learning much easier especially when proper infrastructure is accessible. Coupled with the right technologies, relevant guidelines further brings augmented reality in education in resource limited environments an easy task which is the objective of this research. The research considered experts who are knowledgeable on learning technologies and e-learning mechanisms and some of whom are senior lecturers. Also some students were involved as key respondents who provided data that was analyzed and presented in chapter 4 above.

Findings from this chapter reveal that there are three significant issues that require attention if effective adoption of MAR in learning of is to be achieved. These are Technological, Learning and pedagogical. These are driven by the degree of training, policy implementation and infrastructure maturity. The extent to which these drivers are attained will determine how easy MAR will be integrated with the existing familiar technologies like Virtual learning environments and learning management systems.

Information analyzed and discussed was supported by views, theories and findings from previous related research. All these were guided by the objectives of this study as presented in chapter 1 of this dissertation. This study employed quantitative method of collecting data using self-administered questionnaires. These questionnaires also collected qualitative information of the

respondents like experts on e-learning and learning technologies about certain variables but this was coded and analyzed as discrete information.

The research reveals that most students and teaching staff were not conversant with MAR technologies and that even the few with an idea of MAR lacked skills of using them in learning process a factor that greatly hinders the adoption of MAR in learning (Arum &Roksa, 2011).

Secondly pertaining the availability of the technology and thus technology maturity, learners have not accessed or applied MAR technologies to attain knowledge and as result many prefer the traditional face-to-face model where they download videos and pictures of moving and stationary objects from internet and use imagination of the real situations. This explain the fact that rapid growth of e-learning is occurring without understanding the differences between how Students learn in an online environment and in the more traditional setting (Barab, 2003). Therefore, this study points out strongly the need for management to constantly role out training sessions to all the users and routinely investing in the advanced technology initiatives like MAR which is a modern mechanism for learning.

Like any other technology, MAR adoption can be facilitated by efficient technologies, from the research, again it was evident that like in any resource limited environments issues of supporting technologies like power, internet etc were lacking (Cook & Das, 2007) which considerably affect the adoption of MAR in learning. Because ICTs are electronic in nature, they need power to operate (Laurillard, 2006). This means that the institute management should be begin to take the issue of power supply very important as its absence or delay affect the adoption of all ICTs especially but not limited to MAR. The study suggests a reliable external source of power.

The study identified the need to creating appropriate MAR policy and ensuring that they publicized to the users as guiding tool an how to use MAR. MAR can be made a priority and target ICT tool that will enable efficient and yet cost-effective way learning in today's digital era.

Lastly the research concluded by proposing the need to promote integration of MAR with exiting and familiar technologies like LMS and VLE in order to tap into the advantages of Cost, ubiquitous nature and advancement of privacy since these mobile technologies can enhance

classroom instruction and promote visual, verbal and kinesthetic learning, higher-level thinking, and problem solving but also to offer immediate feedback, hands-on learning, and collaborative instruction (Bataineh & Baniabdelrahman, 2006). These arguments are summarily presented in the proposed framework in chapter 4 above.

5.3 Recommendations

The recommendations are in light of the findings of this research and with the view to improve adoption of MAR at IUIU. For learning to be enhanced with the help of MAR, adoption of this framework is a necessity as it guides the stakeholders in learning on what to do and how to do it.Since MAR technologies are spreading like bush burning fire in developed countries, there is need for continuing professional development in the adoption Process for resource limited environments. Learners and there facilitators should be encouraged and given opportunities for attending internal training programs, workshops/seminars as well as well as other external training sessions offered by private firms and corporations to get exposure to these technologies . However, retraining should not start and end with workshops/seminars, more formal, structured and intensive training programs should be frequently incorporated.

The Institution should equip their labs with modern equipment to enable the smooth learning and teaching using MAR software and hardware. All Stakeholders should be consistently involved in the development, deployment and usage of MAR systems as much as possible to facilitate buy-in-which is a key attribute in adoption of technology-especially new ones.

Lastly technical management should always be on the look out of the latest technologies since that which can work with the existing technologies to boost the adoption of MAR. This will be possible through recruiting competent and technical and qualified staff.

5.4 Future research

More research should be carried out involving other institutions considering augmented reality as a whole within the context of resource rich environments.

Lastly, a research should be carried out to determine a framework that can be used to improve the utilization of MAR technologies in Universities in a context of a developing country.

5.5 Limitations

This research employed a quantitative approach of obtaining primary data using a questionnaire as a tool. However the questionnaire used to collect qualitative data like opinions of experts especially during validation process which was later turned into discrete values using the likert scale instead of conducting interviews and observation methods. This was done so because of limited amount of time and inadequate funding. Thus the information was not exhausted from the respondents because of the rigidity of the questionnaire. Secondly the sample size of IUIU may not have been the right sample to qualify generalizing the results as is the case in the conclusion made in chapter 5.

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APPENDIX I

Questionnaire to be filled in by Lecturers/Students at IUIU

Dear Respondent,

This questionnaire is designed for an academic research project towards developing a framework for adopting Mobile Augmented Reality (MAR) in teaching at University. This project is carried out as a partial fulfillment for the award of a Master's Degree in ICT Management, Policy and Architectural Design of Uganda Martyrs University. The objective of collecting this data using this instrument is to establish the factors that affect the adoption of MAR to forge a way forward through a framework as a tool to promote teaching and learning using modern technologies like Augmented Reality. In that regard, as a respondent, your input is of great value to the success of this project and shall be used only for the purpose of this project. The researcher shall maintain the confidentiality principles during and after the research process.

Thank you for your co-operation.

Section A

(Background Information)

1. In which department do you fall ……
   - Business
   - ICT
   - Technology
   - Medicine
2. What is your designation (*Please tick the appropriate*)

   Student Senior Lecturer Lecturer Assistant Lecturer

3. What is your gender?(*Please tick the appropriate answer*)

Male Female other

4. What is Your age group (in Years)

18-30 31-40 41-50 51above

5. For How long have you been in this Institution

1-2 years 5-10 years

2-5 years above 10 years

SECTION B

Current Status of MAR adoption at the Institution

2 Existing of MAR

2.1 Have you heard about MAR (Mobile Augmented Reality)?

Yes No Not sure

2.2 Does your Institution have MAR (Mobile Augmented Reality)?

Yes No

3 Training in MAR Use.

3.1 Have you had any training in the adoption of MAR in teaching / learning?

Yes No Not sure

3.1.1 If yes in 3.1 above,

Rate the intensity of the training

Intensive Less intensive

Not intensive Not sure

3.1.2 If **yes in 3.1 above**

How often is this training done?

Once in 2 years once in a year

Twice in a year more than twice a year

4 Level of Interest in MAR

4.1 Do you have interest in getting familiar with MAR in conducting/ learning your computer literacy Course?

Yes No not sure

If yes in 4.1 above,

4.1.1 What is your level of Interest in using MAR?

Very high High

Low Very low

SECTION C

STATUS OF THE MAR SUPPORTING EQUIPMENT

1 MAR Policy

1.1 Does your institution have a Clear policy in place about Adopting MAR?

Yes No Not Sure

If yes in 1.1 above,

1.1.1 How applicable is it in adopting MAR

Very applicable applicable not Applicable not sure

Briefly Explain why you think so……

……

Suggest what should be done to improve on the ICT policy related matters in your Institution …….
……

2. ICT EQUIPMENT

2.1 Does your Institution have ICT equipment (Hardware and Software) in place (e.g Computers, internet, projectors MAR apps) to support the use of MAR?

Yes No not sure

If yes in 2.1 above,

2.1.1 Are the ICT equipment (e.g Computers, internet, projectors) sufficient to support the use of MAR?

Very sufficient Sufficient Not sufficient Not at all

Please briefly suggest what can be done to improve this condition
…….
…….

If yes in 2.1 above

2.1.2 How supportive are these equipments in adopting MAR

Very supportive Supportive Not supportive Not sure

Briefly explain why …….
……..

Suggest what should be done to improve the ICT equipment necessary to adopt MAR in your Institution
…….
……

SECTION D

1 Application of MAR

1.1 Do you apply MAR in facilitating your teaching/learning?

Yes No Not sure

If yes in 1.1 above,

1.1.1 How often do you use MAR in conducting teaching/learning?

Very often often Not often Never

Please give a brief explanation for the your answer in 3.1.1 above

……

……

If yes in 1.1above,

1.1.2 Why do you frequently use MAR in conducting teaching/learning?

Acquiring knowledge Processing knowledge Disseminating knowledge Refreshing my mind Other.*(specify)*……..

Explain why……
……

Give reasons why and suggest what should be done to improve the situation

……
……

If yes in 1.1 above,

1.1.4 How long have you been using MAR technologies in teaching/learning?

Less than 1 year between 2 – 5 years above 5 years

If yes in 1.1 above

1.1.5 How do you rate the importance of MAR in teaching/learning?

Very important Important

Not important Not sure

Explain the reasons why ……..
……..

Suggest what should be done to improve the application of MAR in teaching/learning your computer literacy course ……..
…….

SECTION E TECHNOLOGY

1. How do you access MAR services at your Institution?(*select all that apply*) Desktop computers

Laptop
Mobile devices (like ipad, Phones, PDA) ALL the above

Which type of technology would you prefer?
Mobile
Non mobile
Not sure

Explain why …….

……..

Suggest what should be done to improve the technology at your Institution

……
…….

Thank you very much for your cooperation!

APPENDIX II

Questionnaire to be filled in by Experts in e-learning and technology

Dear Respondent,

This questionnaire is designed for an academic research project towards validating the proposed a framework for adopting Mobile Augmented Reality (MAR) in teaching at University attached at the back of the Questionnaire.

Expert's personal information

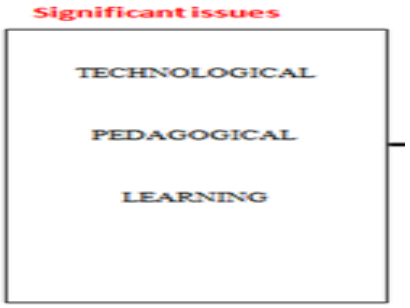
University

Location

Years of experience with MAR use

Each section presents the key concepts of the framework. Validation questions are attached in at the end of each key concept.

Section A: Significant Issues



i) In your opinion, do you agree that multiple technological devices and complex tasks that students have to accomplish affects their learning?

[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

Please give a short rationale for your opinion.

ii) Do you agree that including MAR principles in the study curriculum creates flexible use of MAR?

[ ] Strongly agree
[ ] Agree

[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree
Please give a short rationale for your opinion.

Section B; Resource limited Environments

i) To what extent do you agree that training of students and lecturers in the basics MAR favor the use of MAR in a resource limited environment? [Fill with X]

[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

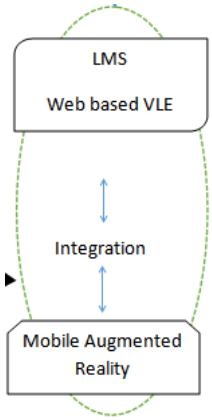
Please give a short rationale for your opinion.

ii) Which infrastructure do you suggest should be available to support the use of MAR in a resource limited environments?

iii) Do you agree that University MAR usage policy should be in line with the existing University values? [Fill with X]
[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

Please give a short rationale for your opinion.

Section D; Intergration with existing management systems



I. Do you agree that MAR should be able to intergrate with the existing environment? [Fill with X]

[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

Please give a short rationale for your opinion

Section E; General Validation Questions

The general validation questions are divided into applicability (E1) and suggestions for improvement (E2**) E1 Applicability:**

II. To what extent do you agree that the proposed MAR framework is usable in practice? [Fill with X]

[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

Please give a short rationale for your opinion

III. To what extent do you agree the proposed MAR framework is useful (giving benefits) in practice? [Fill with X]

[ ] Strongly agree
[ ] Agree
[ ] Neither agree nor disagree
[ ] Disagree
[ ] Strongly disagree

Section F; Suggestion

i) Can you name and explain briefly any deficiency you have observed in the framework?

ii) Can you name and explain the major benefits you have observed in the framework?

iii) Any suggestion to improve the framework? If yes, please state them.

Thank you very much for your cooperation!