AUGMENTED REALTY (AR) IN EDUCATION: ASSESSMENT AND RANKING FRAMEWORK BASED ON FUZZY DELPHI AND HYBRID OF AHP ENTROPY AND VIKOR METHODS

GHAILAN ABBOOD KHUDHAIR AL-SHAFEE

SULTAN IDRIS EDUCATION UNIVERSITY

2021

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"In the name of Allah, the Most Gracious and the Most Merciful"

Praise be to God, first and foremost, Praise be to God, Lord of the worlds, and the Messenger Muhammad, may God bless him and grant him peace, who God sent to be a great teacher of humanity. I would like to express my appreciation and respect to the Malaysian government and the kind Malaysian people who hosted us in our second home Malaysia, I would like to express my thanks to those who participated and provided a useful hand to ensure the success of this research. This research would not have paid off without all the help and support. I am very grateful to my supervisors, Dr. Muhammed Modi Bin Lakolo and Dr. Bilal Bahaa Zaidan, for guiding me during myresearch work. I would like to express my sincere thanks and gratitude to them for their constant guidance, support and patience. I would like to express my sincere thanks. I am also very grateful to my family, especially my brother Abd Al-Kazim Al-Shafiee, my sisters, Wahida, Leila and my dear wife Anhar, who collapsed for their support in blessings, patience, love and encouragement. I also express my thanks and appreciation to my dear friend Karim, and to my dear friend Khaled, Abdallah alamode and Mohamed chyad. Finally, I would like to thank all the friends who helped and encouraged me. Thank you. God bless you.

ABSTRACT

This research aims to assist the educational institutions, teachers and students for the selection of augmented reality (AR) educational applications. Educational institutions face the challenge of evaluating and selecting educational AR applications particularly. Therefore, the main problem is the appropriate selection of instructional augmented reality applications. Framework was proposed to aid the educational institutions in selection and ranking the available AR educational applications to select the best one. Improper selection decisions may cause educational institutions to lose time, effort, and financial costs. The evaluation and benchmarking of AR educational applications are challenging because of the multiple conflicting evaluation criteria. This study constructed a decision matrix (DM) based on the crossover of the 'three evaluation perspectives (usability, immersing and user perspective) with 'six AR educational applications'. The matrix was evaluated using the criteria developed from the evaluation of 15 experts. The alternatives were evaluated by 13 users. Then asked to answer a questionnaire consisting of 90 questions for each application .The AR educational applications were then selected and ranked using multi-criteria decision-making techniques, including the Analytic Hierarchy Process (AHP), ENTROPY and 'VlseKriterijumska Optimizacija I Kompromisno Resenje' (VIKOR). AHP was applied to calculate the weights of the main evaluation criteria, ENTROPY to calculate the weights for evaluation sub-criteria and VIKOR to select and rank the AR educational applications. The results showed that (1) the integration of AHP, ENTROPY and VIKOR effectively solved the AR educational applications benchmarking\selection problems. (2) The rankings of the AR educational applications obtained from internal and external VIKOR group decision making were almost the same.

(3) The best AR educational application was more immersive and more usable. In the objective validation, significant differences were recognized between the groups' scores, thereby indicating that the ranking results of internal and external VIKOR group decision making were valid.

REALITI TERIMBUH (AR) DALAM PENDIDIKAN: PENILAIAN DAN RANGKA KERJA PENARAFAN BERDASARKAN KAEDAH FUZZY DELPHI DAN KAEDAH HIBRID AHP-ENTROPI DAN VIKOR

ABSTRAK

Penyelidikan ini bertujuan untuk membantu institusi pendidikan, guru dan pelajar untuk pemilihan aplikasi pendidikan augmented reality (AR). Institusi pendidikan menghadapi cabaran untuk menilai dan memilih aplikasi AR pendidikan terutamanya. Oleh itu, masalah utama adalah pemilihan aplikasi realiti tambahan yang sesuai. Kerangka ini diusulkan untuk membantu institusi pendidikan dalam memilih dan menentukan aplikasi pendidikan AR yang tersedia untuk memilih yang terbaik. Keputusan pemilihan yang tidak betul boleh menyebabkan institusi pendidikan kehilangan masa, usaha, dan kos kewangan. Penilaian dan penanda aras aplikasi pendidikan AR sangat mencabar kerana terdapat pelbagai kriteria penilaian standard. Kajian ini membina matriks keputusan (DM) berdasarkan Menyeberang dari 'tiga perspektif penilaian (kebolehgunaan, perspektif mendalam dan pengguna) dengan' enam aplikasi pendidikan AR '. Matriks dinilai menggunakan kriteria yang dikembangkan dari penilaian 15 pakar. alternatif dinilai oleh 13 pengguna. Kemudian diminta untuk menjawab soal selidik yang terdiri daripada 90 soalan untuk setiap aplikasi. Aplikasi pendidikan AR kemudian dipilih dan diberi peringkat menggunakan teknik membuat keputusan multi kriteria, termasuk Proses Analisis Hierarki (AHP), ENTROPY dan Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR).). AHP digunakan untuk mengira berat kriteria penilaian utama, ENTROPY untuk mengira berat untuk sub-kriteria penilaian dan VIKOR untuk memilih dan menilai aplikasi pendidikan AR. Hasil kajian menunjukkan bahawa (1) integrasi AHP, ENTROPY dan VIKOR berkesan menyelesaikan masalah penanda aras \ pemilihan aplikasi AR. (2) Peringkat aplikasi pendidikan AR yang diperoleh dari pengambilan keputusan kumpulan VIKOR dalaman dan luaran hampir sama. (3) aplikasi pendidikan AR terbaik lebih mendalam dan lebih berguna. Dalam pengesahan objektif, perbezaan yang signifikan diakui antara skor kumpulan, sehingga menunjukkan bahawa keputusan pemeringkatan keputusan keputusan kumpulan VIKOR dalaman dan luaran adalah sah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

2D	Two dimensions
3D	Three dimensions
AHP	Analytic Hierarchy Process
AR	Augmented reality
ARAs	AR applications
ARCS	Augmented realty creative classroom
ARLEs	Augmented realty learning experiences
ASD	autism spectrum
ASP.NET	Active Server Pages
CAIV	classroom learning is an interactive video
CLSAR	concepts learning scientific Augmented reality
CMS	concept map strategy
CTML	cognitive theory of multimedia learning
DM	Diction matrices
GIM's	Gradual Immersion Method
GIQ	Game Immersion Questionnaire
HMD	head-mounted display
MAR	mobile Augmented reality
MCDM	multi-criteria decision-making
MDAS	mobile digital armillary system
MPNS	mobile phone navigation system

MR	Mixed reality
OBL	observation learning environment
SDK	Software Development Kit
STEM	science, technology, engineering and mathematics
ToM	Target Operating Model
TPCs	Tablets Personal computer
UX	user experience
VE	Virtual Environment
VM	video model
VR	Virtual reality

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Augmented reality in education is surging in popularity in schools worldwide. Through augmented reality (AR), educators are able to improve learning outcomes through increased engagement and interactivity. And that's just for starters. AR even has some surprising advantages over virtual reality (VR).Here are a few ways AR benefits education… and then a few examples of how it has already worked. Augmented Reality (AR) in education features aspects that enhance learning of abilities like problem-solving, collaboration, and creation to better prepare students for the future. It is also good for traditional pedagogy focused on technical knowledge and proficiencies. While AR is still somewhat in its infancy, especially in comparison to virtual reality (VR), it does offer more

cost-friendly options to school districts with tighter budgets – while still providing many of the same features and benefits.

This chapter presents a brief background on the research, the statement of the research problem, the motivation of this research, and the research objectives. Section 1.2 presents a brief background of the research components. Section. 1.3 provides the research problem while in Sections 1.4 and 1.5, the research questions and research objectives are elaborated, respectively. Section 1.6 elaborates on the relationship between research objectives, research questions and research problem. The scope of the research is presented in Section 1.7. The motivation of the research and the significance of the study are outlined in Sections 1.8 and 1.9, respectively. Finally, the outline of the main structure of the thesis is reported briefly in Section 1.10, while Section 1.11 provides the organization of the research.

1.2 Background of the Study

Augmented Reality (AR) can be defined as the upgraded version of reality that extends into virtual reality (VR). Themain difference between AR and VR is that in AR, one feels as though one is still in the real world, while VR separates an individual directly from the real world. In AR, one is kept in the real and virtual world at the same time through the use of a smooth interface and tools and applications designed for this purpose, such as a headset, interactive glasses, tablets and 3D objects. The SR has three main aspects, namely,

(1) the integration of real and virtual objects, (2) the interaction of these things at the same time and (3) the participation of real and virtual things for the same task (Giasiranis & Sofos, 2017; Zhang, Sung, Hou, & Chang, 2014). Previous studies have provided many different definitions, but the consensus is that AR technology combines VR with reality same time (Azuma, 1997; Cai, Chiang, Sun, Lin, & Lee, 2017; Cai, Wang, & Chiang, 2014; Giasiranis & Sofos, 2017; M. B. Ibáñez, Di Serio, Villarán, & Kloos, 2014) Some studies have defined AR as computer-generated images that users see in the real world and provide a composite vision for objects (Dalim, Kolivand, Kadhim, Sunar, & Billinghurst, 2017; Tarng, Lin, Lin, & Ou, 2016). Some definitions have focused on devices that allowed virtual objects to be visualized in a real environment (T.-C. Huang, Chen, & Chou, 2016)(AlShifay, Udofia, Zuhair, & Hassan). Another definition of AR is that it is a direct or indirect presentation of a real environment complemented by virtual elements created by a computer (Gan et al., 2018). Since its advent, AR technology has been used in various fields, including medical, military, industry, tourism, entertainment, advertising, psychology, marketing, engineering and arts. AR technology has also had an effective influence, especially in education. The use of AR technology for education has gained considerable interest because it has stimulated students to be more engaged in learning, enabling them to participate more actively, have a higher concentration and better understanding of the subjects being taught (Giasiranis & Sofos, 2017). Educational researchers have recognized the great potential and significant influence of AR technology on cognitive and emotional learning outcomes (M. B. Ibáñez et al., 2014). Researchers have recognized that AR technology aids students in connecting what they observe in the real world with their previous knowledge and deal with the goals and tasks of the real world

(S.-C. Chang & Hwang, 2018; Hwang, Wu, Chen, & Tu, 2016) because it provides effective learning environments and new opportunities to enhance the learning process (T.-C. Huang et al., 2016). It also combines the digital environment with the real sensory life, allowing the coexistence of the real and virtual, which in turn leads to better interactions for users not only to provide knowledge but also guidance on how to process acquired information (T. H.-C. Chiang, S. J. Yang, & G.-J. Hwang, 2014; Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017; Toledo-Morales & Sanchez-Garcia, 2018). AR technology is also an easy and natural way of teaching because it creates large areas of exploration (Giasiranis & Sofos, 2017). It is also a mature area of psychophysical studies (Azuma, 1997). One of the advantages of introducing AR technology in educational reliability is that it increases students' experiences in real-world environments and their awareness of the environmental context by interfacing digital environments with real environments (Wu, Hwang, Yang, & Chen, 2018). It also enhances reality with additional virtual information (S. K. Kim, Kang, Choi, Choi, & Hong, 2017) and increases the sensory perception of users (M.-B. Ibáñez & Delgado-Kloos, 2018). The learning experience provided by AR technology makes it a good interface for the next generation because it can provide different ways of handling information by designing better learning experiences (Santos et al., 2014). It can also achieve great progress in fostering an educational environment through electronic activities and scientific training activities (C.-p. Chen & Wang, 2015). The results also indicated the significant benefits of using AR technology in education, especially in primary and secondary schools (pre-university education). Previous research has shown that this technology can improve students' education (Radu, 2014). However, this technology has major determinants that must be

considered to be acceptable in the learning field, which gives rise to the necessity of finding appropriate methods for educational institutions to achieve the maximum benefit possible while providing low-cost devices and applications based on AR technology (M.-B. Ibáñez & Delgado-Kloos, 2018). One of the ways to enhance the educational process is by improving the quality of the educational system based on AR technologies, such as usability for applications, immersion and enjoyment for the learner (Pribeanu, Balog, & Iordache, 2017). Hence, identifying the most efficient methods to help educational institutions make the right decision and choose the best AR applications for a given circumstance. Therefore, it is necessary to conduct an assessment and measurement to identify and build a multi-category model that will help these institutions to make the most of this technology in education.

1.3 Research Problem

Main Challenge

The development of AR technology in the past few years have resulted in the creation of millions of applications that offer assistance in the various aspects of practical and scientific life, including the educational aspect. Augmented reality technology has been used in educational institutions to some extent but studies that focus on the use of AR technology in education have obtained varying results.

The AR technology has not been used correctly and widely in the education sector in proportion to its tremendous potential because of the challenges faced by educational institutions, which includes the inability to select the appropriate applications and the lack of experience in its use, the high cost of devices and applications. (T. H.-C. Chiang et al., 2014; Hwang et al., 2016), the lack of the use of appropriate educational applications in education (Joo-Nagata, Abad, Giner, & García-Peñalvo, 2017; Radu, 2014; Saidin, Halim, & Yahaya, 2015; Santos et al., 2014), the difficulty in linking observations of this technology to real-time content (J. L. Chiu, DeJaegher, & Chao, 2015), and the lack of appropriate instructions in the use of AR technology (Cai et al., 2017; Y.-M. Huang & Lin, 2017; Lee, Chen, Wang, & Chung, 2018). Despite the diversity of the existing methods for evaluating assessment, the evaluation criteria still need to be defined and a better method for evaluating AR technology is necessary to identify the best AR application among alternatives (T.-C. Huang et al., 2016).

Based on the above challenges that were found in previous studies, that there is a gap in the use of AR technology in educational institutions, and that the main problem is appropriate selection for educational AR applications. In order to bridge the gap between augmented reality technology and educational institutions and solve the problem, the appropriate choice of educational augmented reality applications, criteria for selecting educational augmented reality applications must be identify from previous studies, based on the identified criteria, It is possible to build a framework from which it can be educational institutions can selection the appropriate application from educational augmented reality applications..

Usability, immersion and user perspective are the primary quality standards that influence user acceptance of the AR because these standards determine the efficiency of application design (Lee et al., 2018).

Although the AR apps is available, choosing one is a difficult process. Consequently, the institution encountered difficulties in evaluating and comparing the AR applications to determine the best and an incorrect decision on the selection of the AR application may cause the institution loss in terms of effort, time and financial costs (R.-C. Chang, Chung, & Huang, 2016) and also affect professional development (Zhang et al., 2014), resulting in lesser motivation among students to learn (R.-C. Chang et al., 2016). To help the decision-maker, choose the best AR alternative, a multi-perspective evaluation to evaluate the AR application should be recognized. Thus, the problem of the evaluation process of AR is a complex multi-criteria problem. The main problem is identified from three phases. The first phase involves the process of evaluating multiple criteria. The second phase is the identification of the importance of each standard. The third phase pertains to the variability of data among the available alternatives identified by multiple criteria. According to the identified phases, AR evaluation requires assessing multiple criteria and identifying which ones have the most influence on the decision to choose AR applications (alternatives). The process of choosing alternatives can be considered problems with MCDM. An integrated approach to multi-perspective AR evaluation is needed. However, the method for choosing the best AR alternative has not been explored in previous studies, Hence, this thesis explores the issues of standardisation of criteria and importance of criteria.

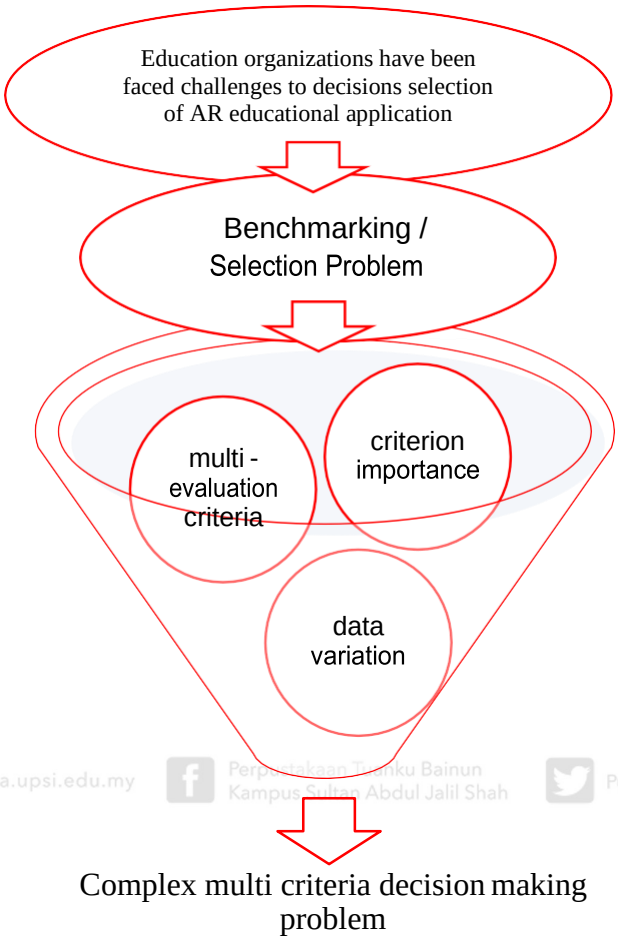

Figure 1.1. Problem Statement Configuration

1.4 Research Questions

The following research questions were drawn up to set the direction of this research:

1- What is the current literature on the evaluation of educational AR applications?

2- What are the suitable evaluation criteria for measuring the components (usability, immersion and user perspective) of AR educational applications?

3- How is the evaluation decision matrix constructed based on the determined evaluation criteria?

4- What is the ranking framework based on construction decision matrix?

5- Is the proposed selection and ranking framework valid?

1.5 Research Objectives.

1- To investigate previous studies related to evaluation educational AR applications.

2- To identify the evaluation criteria for AR applications based on three components (usability, immersion and user perspective).

3- To construct an evaluation decision matrix based on identified evaluation criteria.

4- To develop a ranking framework based on construction decision matrix.

5- To validate the proposed selection and ranking framework.

1.6 Relationship between Research Objectives, Research Questions and Research Problem.

Research questions are outlined to provide the direction and focus of the research while the research objectives provide answers to the research questions. Table 1.1 presents the research questions and research objectives and determines what part of the research problem will be addressed when each research objective is achieved.

Table 1.1

Link among Research Questions, Objectives and Problem

Research Questions	Research Objectives	Research problem mapping Specific Problem	General problem
Q1) What is the current literature on the evaluation of educational AR applications?	1- To investigate previous studies related to evaluation educational AR applications.		
Q2) What are the suitable evaluation criteria for measuring the components (usability, immersion and user perspective) of AR educational applications?	2- To identify the evaluation criteria for AR applications based on three components (usability, immersion and user perspective).		Selection problem (application)
Q3) How is the evaluation decision matrix constructed based on the determined evaluation criteria?	3- To construct an evaluation decision matrix based on identified evaluation criteria.	Multi Evaluation criteria problems.	
Q4) What is the ranking framework based on construction decision matrix?	4- To develop a ranking framework based on construction decision matrix.		
Q5) Is the proposed selection and ranking framework valid?	5- To validate the proposed selection and ranking framework.		

1.7 Scope of the study

The scope of this research is defined by the following considerations:

1. This research focuses on the selection and benchmarking of the methodologies of educational AR applications based on multi-criteria decision making in the selection of educational AR applications.

2. A framework is developed according to multiple criteria analysis to select the most immersive educational AR application. Figure 1.2. Provides a general view of the research and presents the research method, type and field.

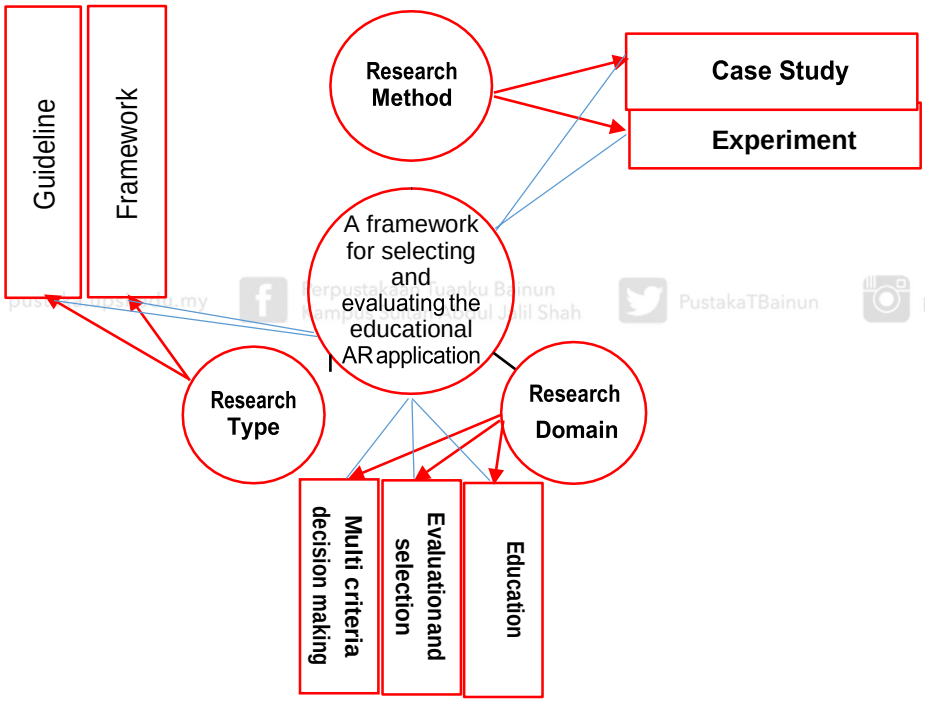

Figure 1.2. Research Scope

This study is multi-disciplinary research that involves the benchmarking of methodologies for the selection of the educational AR applications for primary, intermediate and high school (pre-university) levels to evaluate and choose the correct educational AR applications that would ensure that complete information can reach

students, reduce time and effort on the part of the teachers and enable educational institutions to keep pace with modern technology and reduce costs. This study is designed to address the evaluation/selection problem for educational AR applications.

In this study, educational AR applications (biology and human anatomy) are used in the user experience to generate the required data that will be used to demonstrate the concept of the proposed methodology. The test samples were from teachers and students.

Search results indicate the types of research outputs of this study. The first output is a methodology implemented through several steps to improve the process of assessing and selecting educational AR applications.

The integrated MCDM method used for testing (evaluation and selection) was based on several criteria to improve the evaluation and selection decision for educational AR applications. Based on the above, this research belongs to the field of information technology and management.

1.8 Motivation

AR's relative seamlessness of digital objects within the "real world" encourages interactivity and engagement. It maximizes students' ability to spend their time learning curricular subjects while minimizing the time spent learning how to use the new tech. In

addition, as discussed in Stanford News on VR's applications within the classroom and "the effect of the body's actions on the mind," AR can also inspire empathy in an individual. It offers two-dimensional methods of presenting information versus the traditional one-dimension. This combination of interactivity and engagement with emotion, in turn, could enhance the ability of students to remember what they've learned– and lead to faster acquisition of information and skills. Therefore, AR provides students with opportunities to deepen their knowledge within several areas, including (Reading, Working with numbers, spatial concepts, and Content creation), this can include everything from field trips to exposure to training within different professions. When combined with assignments involving teamwork, AR similarly helps provide new opportunities for students to learn how to communicate and collaborate with one another.

Most studies have confirmed the effectiveness and effect of AR technology in the educational process and many benefits of using this technology in education have been observed especially in primary and secondary schools (pre-university) (Radu, 2014). The quality of the education system based on AR is an important factor for the success of the educational process. A successful system has the advantages of ease of use, enjoyment, immersion and scientific benefit (Pribeanu et al., 2017). When the application has these advantages, students become more enthusiastic and focused. One of the most difficult and important issues in the educational process is providing an appropriate strategy and ensuring effective teaching to encourage students to focus on what they need to know and observe (Hwang et al., 2016). Many applications of enhanced reality are available in the field of education and various disciplines, such as physics, chemistry, biology,

mathematics, history, geography, languages, arts etc., making it difficult for teachers to choose because most teachers do not have experience in the use of AR technology and in choosing the appropriate application of the appropriate subject (Hung, Chen, & Huang, 2017; Wei, Weng, Liu, & Wang, 2015). Many teachers also face the fear of failure to use technology (Havlíčková et al., 2018) because of the absence of training or experience in its use (Toledo-Morales & Sanchez-Garcia, 2018). Some teachers also fear being too reliant on AR technology due to a lack of awareness (Tekedere & Göke, 2016; K. Tian, Endo, Urata, Mouri, & Yasuda, 2014). No guidelines are available for teachers to choose and use applications (Santos et al., 2014), making it difficult for them to choose the right educational AR application. As a result of these reasons, we note the limited use of AR technology in education. Hence, the main motivation of this study is to enable teachers to make the right decision in choosing the right application for the right topic. The choice of appropriate application in education will make the most of this technology in transferring information to students well, increasing the cognitive reasoning of students and their effective participation and shortening the time and effort for the teachers, thus making the technology acceptable and suitable as a useful teaching tool (Giasiranis & Sofos, 2017; Y.-M. Huang & Lin, 2017; Pribeanu et al., 2017). This study will be very useful for primary and secondary schools because it can serve as a guide in selecting the appropriate application in the teaching process. This study can motivate researchers to propose a mechanism for selecting educational AR applications that support teaching staff and educational institutions. Currently, no studies on the mechanism of selection of augmented reality applications and their associated assessment and measurement using MCDM can be found in the literature.

1.9 Significance of the study

1.9.1 Practical significance of the study

In practical terms, through the proposed measurement methodology to select and ranking educational AR applications and technologies, educational institutions will be able to choose the appropriate applications for the appropriate subject matter and contribute to the success of the educational process, thereby increasing academic achievement and interest of students as well as enhancing their collective participation, enthusiasm, concentration and activity (Cai et al., 2017; Giasiranis & Sofos, 2017; Pribeanu et al., 2017). Through the proposed comparison methodology, the decisions of educational institutions on the selection and ranking of appropriate applications will be more accurate and based on a scientific method that will be developed and tested according to the proper scientific basis.

1.9.2 Theoretical importance the study

This study contributes to the literature by adopting the methodology for reviewing the methodological literature, providing an overview of the current information and evidence regarding the use of AR technology in education and the selection and ranking approach, and highlighting the trends in research on this topic. This study also contributes to the bridging of the lack of studies in this field and classifying the relevant literature. The classification can impose a type of organization on the collection of publications by

classifying different works into a purposeful, easy to manage and coherent design that will enable researchers to gain important insights on the subject area, identify potential trends in research in this field and reveal gaps in the literature and map studies related to the appropriate choice of AR educational applications in education. This study also provides a guide to the most important criteria that should be adopted in evaluating AR applications in the educational process.

1.10 Main terms

Main terms of the study:

Augmented reality refers to programs that combine virtual reality with reality at the same time through modern applications called augmented reality applications. These applications help to make virtual things closer to the truth, which could facilitate education and ensure that the full information reaches the recipient. In this study, it refers to those used in the medical field, specifically biology (Anatomy of the human body), and for an age group starting from four years old and above. These applications include Complete Anatomy Platform, Anatomy insight heart, Anatomy AR + for Merge Cube, Anatomy Luke AR, Anatomy the Brain AR App, Human Anatomy 4D- Mixed Reality.

Comparison process refers to the process of evaluating each application separately with a group of users through a specific set of criteria.

Multi-criteria decision-making is an umbrella term that describes a set of formal approaches that seeks to consider multiple criteria in helping individuals or groups to explore appropriate and correct decisions.

1.11 Organization of research

This study is composed of five chapters. Figure 1.3 illustrates the structure of the study. The background of research, research problem, research questions, research objective, the relationship between research questions and research objective, research scope, research motivation and significance of the study are outlined in Chapter One. The remainder of the study is organised as follows. Chapter Two provides the theoretical background (Literature review), Chapter Three contains the methodology research, Chapter Four provides the details of the results and Chapter Five lists the conclusion and suggestions for future work.

Chapter Two: Literature Review. In this chapter, previous studies that focused on the evaluation of AR technology in the educational process, particularly in the primary, intermediate and secondary schools (pre-university) are discussed. This chapter identifies and describes in detail the main criteria for assessment and measurement. The current assessment and measurement methods are also discussed with related problems and issues. This chapter also includes the theoretical background of the multi-criteria decision-making (MCDM) process, presents the common MCDM methods, and explains the main MCDM methods, which include Analytic Hierarchy Process (AHP), and ENTROPY and the

VIKOR methods. It also explains useful techniques that enable decision making on multi-standard problems. The main purpose of this chapter is to identify the research gap and challenges and provide recommendations on possible solutions.

Chapter Three: Research Methodology. This chapter describes the requirements for developing the proposed framework for assessing and selecting the best educational AR applications and the following stages. The methodology is designed in five main phases, namely, the investigation, identification, decision matrices (DM), development and verification phases. This chapter will detail how the five research objectives will be achieved through these phases.

Chapter Four: Results and Discussion. This chapter presents the results and discussion of the selection and ranking methodology for educational AR applications framework. The chapter demonstrates how the results of the proposed methodology resolve the problems mentioned in the problem statements. It also presents the results of the validation process.

C**hapter Five:** Conclusion and Contributions. This chapter concludes and summarizes the research contributions made. The research limitations, future research proposals and conclusions are also reported.

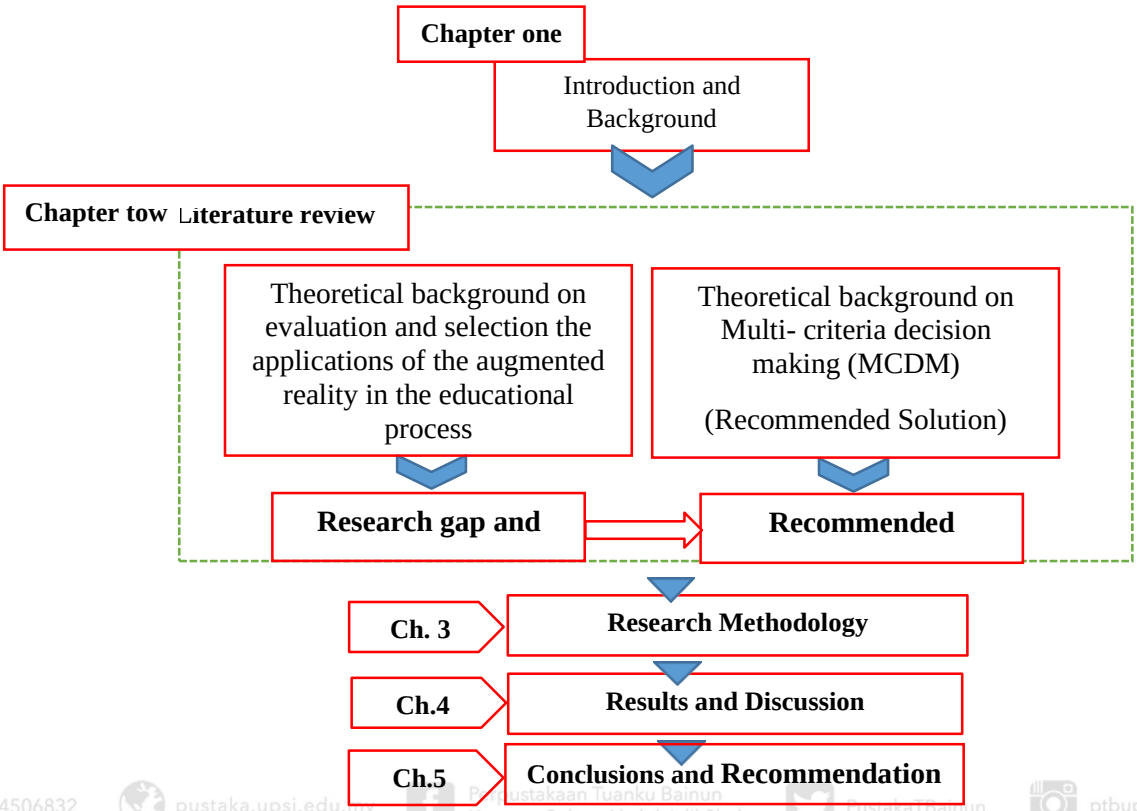

Figure 1.3. The Structure of Study