ADOPTION OF THE METAVERSE SYSTEM FOR SCIENCE EDUCATION AT THE ELEMENTARY SCHOOL LEVEL IN DUBAI

RAGHAD MOHAMMAD AL-FAISAL

UNIVERSITI PENDIDIKAN SULTAN IDRIS

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ABSTRACT

The Metaverse is an interactive digital space that enhances learning by enabling real-time communication and collaboration. While its role in higher education has been widely studied, its adoption in primary education remains underexplored. Given Dubai's learning environment, which prioritises technology in education, understanding students' perceptions of Metaverse integration in science learning is crucial. However, research on its adoption at the primary school level remains limited, especially in assessing key influencing factors through a structured model. This study aims to examine the factors influencing the adoption of Metaverse systems among primary school students. The study employs a quantitative approach with a cross-sectional survey design. A total of 580 students from four primary schools in Dubai were selected as respondents using a simple random sampling method. Data collection was conducted using a questionnaire developed based on a combination of the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). The key study variables examined include immersion, interaction, imagination, and self-innovation. Structural Equation Modelling (SEM) and Importance-Performance Map Analysis (IPMA) were used for data analysis. The findings indicate that immersion ($\beta=0.238$, $p < 0.001$), interaction ($\beta=0.142$, $p < 0.05$), imagination ($\beta=0.262$, $p < 0.001$), and personal innovativeness ($\beta=0.171$, $p < 0.001$) significantly influence students' perceptions of the metaverse's usefulness and ease of use. Additionally, perceived usefulness ($\beta=0.311$, $p < 0.001$), effort expectancy ($\beta=0.240$, $p < 0.001$), social influence ($\beta=0.150$, $p < 0.01$), and facilitating conditions ($\beta=0.126$, $p < 0.05$) also positively affect students' intentions to use the Metaverse. The results suggest that the adoption of the Metaverse in primary school learning is influenced by perceived usefulness, effort expectancy, social influence, facilitating conditions, immersion, interaction, imagination, and personal innovativeness. The study's implications can assist educators and policymakers in developing effective strategies for integrating the Metaverse into learning.

PENERIMAGUNAAN SISTEM METAVERSE DALAM PENDIDIKAN SAINS PERINGKAT SEKOLAH RENDAH DI DUBAI

ABSTRAK

Metaverse ialah ruang digital interaktif dan imersif yang meningkatkan pembelajaran melalui komunikasi dan kerjasama secara maya menggunakan avatar digital dalam masa nyata. Peranannya dalam pendidikan tinggi telah dikaji secara meluas, namun penerimagunaannya dalam pendidikan rendah masih kurang diterokai. Persekitaran pembelajaran di Dubai mengutamakan teknologi dalam pendidikan dan mementingkan kefahaman murid terhadap integrasi metaverse dalam pembelajaran Sains. Namun, penyelidikan mengenai penerimagunaannya di peringkat sekolah rendah masih terhad. Oleh itu, kajian ini bertujuan untuk mengkaji faktor-faktor yang mempengaruhi penerimagunaan sistem metaverse dalam kalangan murid sekolah rendah. Kaedah kajian berbentuk kuantitatif dengan reka bentuk tinjauan keratan rentas. Sampel kajian seramai 580 orang murid daripada empat buah sekolah rendah di Dubai yang dipilih sebagai responden dengan menggunakan kaedah persampelan rawak mudah. Pengumpulan data dilaksanakan dengan menggunakan instrumen soal selidik yang digubal berdasarkan kepada gabungan model *Technology Acceptance Model* (TAM) *dan Unified Theory of Acceptance and Use of Technology* (UTAUT). Pemboleh ubah utama kajian yang dikaji ialah imersif, interaksi, imaginasi, dan inovasi kendiri. Penganalisisan data dilakukan secara *Structural Equation Modeling* (SEM) dan *Importance-Performance Map Analysis* (IPMA). Dapatan kajian menunjukkan bahawa imersif ($\beta=0.238$, $p < 0.001$), interaksi ($\beta=0.142$, $p < 0.05$), imaginasi ($\beta=0.262$, $p < 0.001$), dan inovasi kendiri ($\beta=0.171$, $p < 0.001$) secara signifikan mempengaruhi persepsi murid terhadap penerimagunaan metaverse. Selain itu, kegunaan yang dirasai memberi impak ($\beta=0.311$, $p < 0.001$), jangkaan usaha ($\beta=0.240$, $p < 0.001$), pengaruh sosial ($\beta=0.150$, $p < 0.01$), dan kemudahan persekitaran yang menyokong ($\beta=0.126$, $p < 0.05$) turut memberi kesan positif terhadap minat murid untuk menggunakan metaverse. Hasil kajian ini menunjukkan bahawa penerimagunaan metaverse dalam pembelajaran sekolah rendah dipengaruhi oleh faktor kegunaan yang dirasai, jangkaan usaha, pengaruh sosial, dan kemudahan yang disediakan, imersif, interaksi, imaginasi, dan inovasi. Implikasi kajian ini dapat membantu pendidik dan pembuat dasar dalam membangunkan strategi integrasi metaverse dalam pembelajaran dengan berkesan.

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LIST OF ABBREVIATIONS

3D	Three-Dimensional
AVE	Average Variance Extracted
CA	Cronbach's alpha
CMB	Common Method Bias
CR	Composite Reliability
DOI	Diffusion of Innovation
E-learning	Electronic Learning
HMD	Head-Mounted Display
HTMT	Heterotrait-Monotrait Ratio of Correlations
ICTs	Information and Communication Technologies
IPMA	Importance Performance Map Analysis
KHDA	Knowledge and Human Development Authority
MM	Motivational Model
MPCU	Model of Personal Computer Utilization
PA	Dijkstra-Henseler's
PLS-SEM	Partial Least Squares Structural Equation Modeling
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
SCT	Theory, the Social Cognitive Theory
SEM	Structural Equation Modeling
SLR	Systematic Literature Review

SRMR	Standard Root Mean Square Residual
STEM	Science, Technology, Engineering, and Mathematics
TAM	Technology Acceptance Model
TEL	Technology Enhanced Learning
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UAE	United Arab Emirates
UTAUT	Unified Theory of Acceptance and Use of Technology
VE	Virtual Environment
VR	Virtual Reality

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CHAPTER 1

INTRODUCTION

1.1 Overview

In this chapter, the problem definition is addressed, as well as the research motivations. The study goal is explicitly stated. A brief description of the research questions is provided, as well as the methodology used. Lastly, a summary of the thesis and a synopsis of the chapters are provided which implies this chapter provides a comprehensive outline.

1.2 Research Background

Due to time and location restrictions, as well as the difficult job of adequately encouraging each student, traditional classroom learning may not always be relevant

and engaging to students (Rodrigues et al., 2019). Because the vast bulk of the globe's 900 million uneducated adults, 130 million unschooled children, and many more dissatisfied school leavers whom conventional formal learning structures have only been capable of reaching to a very minor level in Arab countries, there is a supplemental, urgent necessity of accessible educational activities in these nations (Abdelraheem, 2006; Alqudah et al., 2022). Additionally, it is impossible to assist each student in a traditional classroom given their varied traits (Ally, 2004; Alqudah et al., 2022).

Several academic institutions are adopting distance learning, commonly referred to as "e-learning," which combines traditional courses with online learning alternatives to reduce expenses (Al-Hunaiyyan et al., 2016; Qazi et al., 2024). The development of information and communication technologies (ICTs) has quickly altered the globe and transformed traditional classroom instruction into Technology Enhanced Learning (TEL) frameworks (Ismaila & Ibrahim, 2024; Ukpe, 2023). To improve education quality and allow stakeholders to participate in teaching and learning programs at their educational institutions, academic institutions are integrating these technologies. Depending on blended learning models, these technologies can be integrated into the classrooms or employed to grant remote participation to a novel teaching landscape depending on the suggested distance learning model (Gonzales & Gonzales, 2024). It will be intriguing to explore how the expanded usage of distance learning will impact enrollment and admission rates for students in Arab schools. Due to the fact that metaverse system has been developed recently to solve problems in the virtual environments, few studies have focused on its adoption and acceptance by users in the developed countries, hence, computer scientists and researchers aimed to rapidly

develop the aspects of the virtual environment (Akour et al., 2022). Due to the advancement of the Internet and the widespread distribution of social media, cheap and easy access is provided to hardware and software to offer enhanced digital content that is signified by three-dimensional (3D) virtual environments (Akour et al., 2022; Collins, 2008). According Stephenson (1992) coined the term *metaverse*, whereby an immersive 3D virtual environment was explained through a science fiction novel. The development of the metaverse helps in carrying out everyday communication and interaction among humans. Hence, the metaverse may be referred to as a world that virtually enhances physical space and physical reality (Akour et al., 2022). It is an integration of the real as well as physical universe through which the users can imagine various and myriad digital mirrors of the actual world and mirrors that are not present in the actual world for different purposes (Akour et al., 2022; Arcila, 2014).

A large number of studies have been conducted in various universities and educational institutions, with the focus of these studies being on the metaverse (Akour et al., 2022; Al-Maroof et al., 2024; Alawadhi et al., 2022; AlHamad et al., 2022; Almarzouqi et al., 2022; Salloum et al., 2023). The metaverse was used by the researchers in an educational setting, concentrating on the adoption of a problem-based technique in which students and teachers can present the problem and identify potential solutions in the imaginary world with the help of three-dimensional classes and the avatar (Alkhwaldi, 2024; Kanematsu et al., 2012).

Jeon and Jung (2021) determined that a metaverse platform is a vital tool using which learners can enhance their motivation and immersion (Alfaisal et al., 2022). It allows them to generate real feelings regarding the use of innovative learning

approaches and acquire self-directed learning experiences (Alfaisal et al., 2022). In addition, the significance of using the metaverse system in different fields of study globally was demonstrated by Aburayya et al. (2023), Akour et al. (2022), and Farjami et al. (2011). The studies cited demonstrate the metaverse system's potential as an innovative educational tool that enhances students' learning experiences and promotes engagement, creativity, and collaboration. They also highlight the system's versatility in a variety of contexts, such as virtual training, cultural heritage preservation, disaster management, and tourism. The focus of these studies was to employ the metaverse system in real-life experiences to obtain solutions to problems, demonstrating the system's applicability in different fields. Thus, it is important to develop a conceptual model that explains the significant role of the metaverse system from the perspective of students. The findings of these studies underscore the growing significance of the metaverse system in shaping the future of education and technology.

The research model is capable of examining whether the metaverse system is effective, focusing on the perception of students from a distinct point of view. The study aims to create a research framework representing two crucial research models: “TAM & UTAUT”. Along with several external variables, such as “immersion, interaction, imagination, and personal innovativeness”.

1.3 Problem Statement

The basic purpose of education is to provide students with the knowledge and training that are considered important in society to equip them for life, job, and citizenship

(Wittich et al., 2017). The act of enabling learning, acquiring knowledge, abilities, or constructive values is typically referred to as education. Enhancing graduates' credentials, abilities, and skills throughout the educational process is the responsibility of the educator (Dewey, 2007).

Classes typically include two components theoretical and practical, including activities, labs, or internships. In theoretical courses, knowledge is transferred among a sizable group through lectures that may also include debates. The demands of students and the job prospects throughout time compelled modifications in the educational system (Blumenfeld et al., 1991). The practical aspect had been given precedence. Due to the technical difficulty, the need for conceptual thought, and the reality that these notions are not physical, many students have difficulty comprehending ideas, particularly in science courses (Zheng et al., 2015). Basic flaws limit continued research and improvement of more complex issues. Students are not allowed to self-configure lab equipment, encounter emergencies, or undergo the impacts of configuration errors that could cause equipment breakage. Practical exercises, which are dependent primarily on sophisticated research equipment, must be performed under oversight. Additionally, there is no way to practice and make up lost time outside of the lab timetable. Contemporary technologies, including online courses (Magdalene & Sridharan, 2018), blended learning (Al-Maroof et al., 2021; Halverson et al., 2017), various computer-based platforms (Van der Kleij et al., 2015; Zhang et al., 2018), and many more, are the present alternatives. This tool enables students to revisit the same material multiple times, make mistakes, and improve from them. The edtech industry can enhance learning outcomes for the bulk of students, according to numerous instances of hardware and software that have proved effective in educational procedures

(Collins & Halverson, 2018). Sophisticated new technological resources are being introduced by an increasing number of educational institutions worldwide to assist them in better fulfilling the needs of their heterogeneous student demographics.

Digital learning materials, particularly those from open academic services, are overtaking classical books (Atkins et al., 2007). Traditional copybooks have been supplanted with notebooks, tablets, or smartphones with specialized apps (Ally, 2009), and personalized learning (FitzGerald et al., 2018) and distance learning (Kaye & Rumble, 2018) are utilized to adapt the educational experience to each student's educational abilities, shortcomings, interests, and aspirations. It is commonly recognized that the usage of Information and communication technologies has been shown to increase students' perceptions of education (Hõrak, 2019; Lieshout et al., 2018). It is an area of study that is expanding quickly, constantly searching for new technical alternatives. The interactive computer-generated world known as metaverse, which was previously only used for gaming, is now being used for professional development in fields including education, health, and psychiatry forces.

A large number of studies have been conducted in various universities and educational institutions, with the focus of these studies being on the metaverse (Al-Adwan & Al-Debei, 2023; Al-Adwan et al., 2023; AlDhanhani et al., 2023; Di Natale, Bartolotta, et al., 2024; Di Natale, Repetto, et al., 2024; Galindo-Manrique et al., 2023; Shwedeh, 2024; Sim et al., 2024; Yang et al., 2022). The metaverse was used by the researchers in an educational setting, concentrating on the adoption of a problem-based technique in which students and teachers can present the problem and identify potential

solutions in the imaginary world with the help of three-dimensional classes and the avatar (Barry et al., 2009; Farjami et al., 2011; Kanematsu et al., 2012, 2013).

Jeon and Jung (2021) determined that a metaverse platform is a vital tool using which learners can enhance their motivation and immersion. It allows them to generate real feelings regarding the use of innovative learning approaches and acquire self-directed learning experiences. In addition, the significance of using the metaverse system in different fields of study globally was demonstrated by Farjami et al. (2011), Han (2020), and Kanematsu et al. (2013). The focus of these studies was on formulating real-life experiences where the metaverse system is employed to obtain solutions to the problem. This shows that a conceptual model needs to be developed that can explain the significant role of the metaverse system from the point of view of students. The conceptual model is capable of examining whether the metaverse system is effective, focusing on the perception of students from a distinct point of view.

Despite the numerous studies on the use of metaverse systems in educational settings (Akour et al., 2022; Alfaisal et al., 2022; Barry et al., 2009; Farhi, 2024; Farjami et al., 2011; Kanematsu et al., 2012, 2013; Wang et al., 2024), few studies have specifically focused on the adoption of these systems in problem-based techniques for science education at the elementary level in Dubai schools.

Previous studies have mainly examined the potential benefits of using metaverse systems, such as enhancing motivation, immersion, and self-directed learning experiences, but have not adequately explored students' perceptions of these systems. Therefore, a research model that examines the effectiveness of the metaverse

system in science education from the students' perspective is needed to fill this gap in the literature.

The present study has the aim of examining the factors that have an impact on the adoption of the metaverse system for science education at the elementary level in Dubai schools by finding out the degree to which the adoption of the metaverse system is affected by “perceived ease of use and perceived usefulness”. In addition, it also aims to determine how “perceived usefulness and perceived ease of use” affect immersion, interaction, imagination, and personal innovativeness. Finally, the study aims to develop a correlation between a users’ degree of satisfaction and the adoption of the metaverse system; concentrating on the aspects of “performance expectancy, effort expectancy, social influence, and facilitating condition”.

1.4 Research Objective

a) To analyze the challenges associated with adopting the metaverse system in elementary education institutions.

b) To assess students’ perceptions of the metaverse system for science education at the elementary school level in Dubai schools.

c) To identify and evaluate the most influential factors affecting the adoption of the metaverse system for science education at the elementary school level in Dubai schools.

1.5 Research Question

While metaverse system developments have been employed in e-learning, three study problems ought to be addressed before they can be integrated into the UAE's elementary education e-learning framework.

Q1: What are the challenges and issues in metaverse system studies and possible improvements?

Q2: What factors determine behavioral intention in the adoption of e-learning through the metaverse system?

Q3: What are the primary factors that have a favorable impact on metaverse system adoption of e-learning?

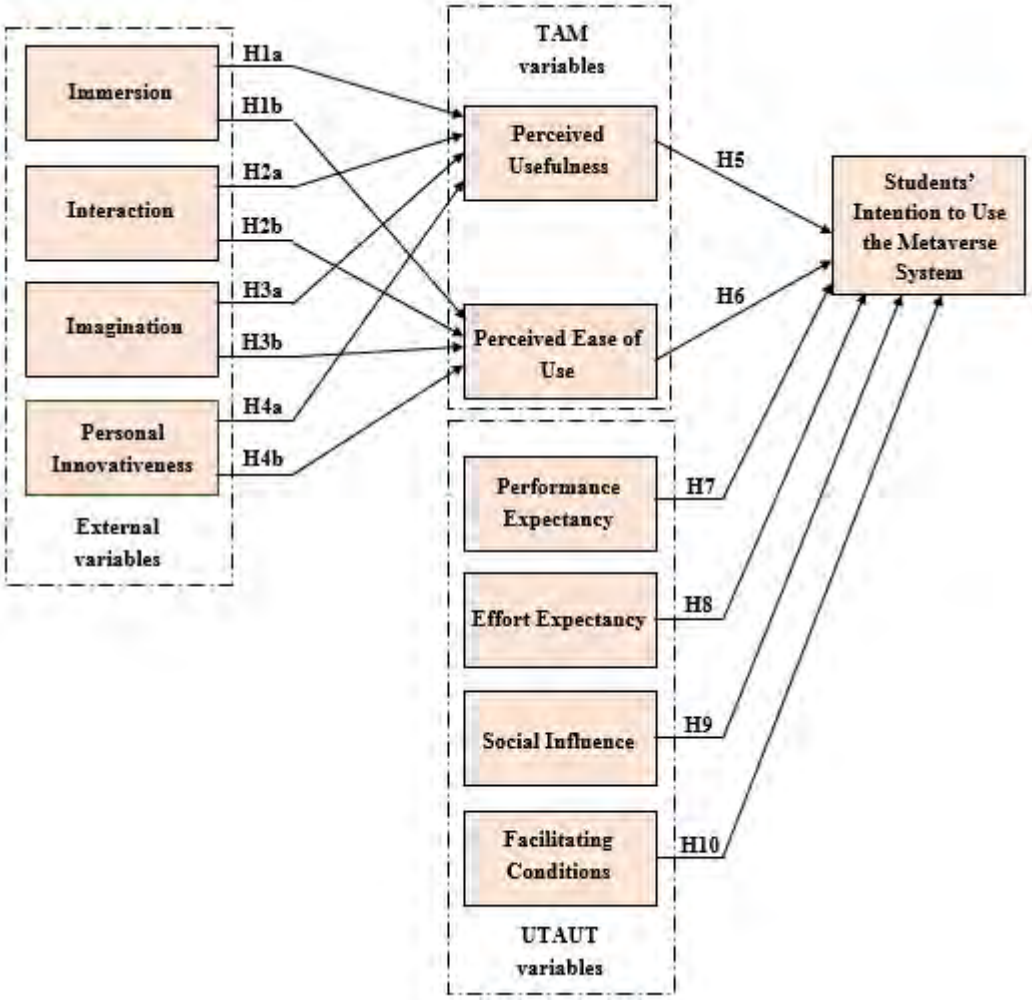
1.6 The Research Model

The novel metaverse systems in education, in terms of students' views regarding their employment, are evaluated using the research methodology to identify and fill gaps. The views of elementary school students in the Knowledge and Human Development Authority (KHDA) (Dubai schools) are the focus of this study. The research will utilize a quantitative approach with two questionnaire surveys: a self-administered survey will be sent to students at Dubai National School, and an online survey will be shared among Dubai school students. A total of four schools will be contacted. The research will use the extended model (TAM & UTAUT) as a framework to examine the adoption or acceptance of the Metaverse System (see Chapter Three for further details) refer to

Figure 1.1. A quantitative research methodology will be employed, and purposive sampling will be used. The hypotheses are based on existing theories and are consistent with the metaverse context. Structural equation modeling (SEM) will be used to analyze the measurement model, including components of reliability and validity. The final model will be evaluated using the thresholds provided and good-fit values.

Figure 1.1

The Research Model



1.7 Operational Definition

Following operational definitions and term definitions that describe the essential ideas depending on the research's perspective will be employed in the research.

1.7.1 Avatars

An electronic image that may be edited by a computer user and depicts something.

1.7.2 Digital Twins

A digital twin is a virtual depiction that acts as a physical object or process's real-time digital equivalent.

1.7.3 Distance Learning

When a student and instructor are divided in both time and distance, this is referred to as distance learning. It refers to the schooling of individuals who might not constantly be physically available at a school.

1.7.4 E-learning

E-learning is primarily centered on employing computers and the Internet, although teaching can also take place in or outside of formal classroom settings. E-learning is a standardized teaching-based learning system that makes use of electronic resources.

1.7.5 Metaverse

A metaverse is a network of 3D virtual worlds that are mostly utilized for social interaction. The integration of virtual reality and augmented reality devices allows for the creation of the metaverse, an idealized version of the Internet that is a unified, universal, and immersive virtual world.

1.7.6 Mixed Reality

A metaverse is a network of 3D virtual worlds that are mostly utilized for social interaction.

To create new habitats and representations where physical and digital objects co-exist and communicate in real-time, real, and virtual worlds must be combined. This is known as mixed reality.

1.7.7 Second Life

Second life in an online virtual world can be had by creating an avatar on the online multimedia platform known as Second Life.

1.7.8 Systematic Literature Review (SLR)

A systematic review is a scientific analysis of the data on a well-described subject employing critical techniques to identify, define, and evaluate relevant research.

1.7.9 Technology Acceptance Model (TAM)

The moment at which users use technology is during actual system use. The information systems theory known as the technology acceptance model models how people learn to accept and use technology. An element that influences people's decision to use technology is their behavioral intention.

1.7.10 Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT seeks to clarify users' initial information system usage intentions and later usage behavior. In "User Acceptance of Information Technology: Approaching a

Holistic Perspective," Venkatesh and others developed the unified theory of acceptance and use of a technology called a technology acceptance model.

1.7.11 Virtual Reality (VR)

Virtual reality has a variety of uses in business, education, and entertainment. A simulated environment known as virtual reality can be nearly identical to or dissimilar from the real world.

1.7.12 Quantitative Methodology

Quantitative methodology is a research approach that involves collecting and analyzing numerical data using predetermined measures to study a phenomenon or problem, commonly used in fields such as psychology, sociology, economics, and natural sciences.

1.8 Study Limitations

This study provides significant insights into the adoption of metaverse technology in education but has limitations that suggest directions for future research. The primary limitation is its reliance on cross-sectional data from 580 participants in Dubai, which restricts causal inference. Future studies could adopt experimental designs and expand

the geographical and cultural scope to include diverse regions like Southeast Asia. Additionally, while the study utilizes quantitative methods through an online questionnaire, incorporating qualitative methods could deepen understanding of individual perceptions and motivations. Overall, expanding research methods and exploring metaverse technology in various educational contexts could enhance global understanding of its integration and acceptance.

1.9 Importance of Research

Even though most of the research on the uptake of e-learning systems employing metaverse systems has been undertaken in many developed nations (Andembubtob et al., 2023; Dahan et al., 2022; Lee & Jang, 2023; Teng et al., 2022), there is a striking paucity of empirical studies that emphasize the Arab world (Aburayya et al., 2023; Akour et al., 2022; Alfaisal et al., 2022; Salloum et al., 2023).

One of the main reasons for undertaking this research in the United Arab Emirates (UAE), with its values and customs, is to fill a void in the existing literature. Furthermore, as previously stated, the research was able to demonstrate that developing-world cultures had a lower rate of adoption. There are currently no recent numbers published on the adoption of the metaverse system in the UAE. As a result, empirical studies that focus on this subject in the UAE are extremely important.

The causes behind this are rather obvious. Studies in the UAE will indeed highlight the significant reasons for adoption; reasons that can be discussed directly

with other regional cultures, and much more broadly with other cultures that reflect some of the features used in the research's findings, with caution. Moreover, identifying these common variables will aid researchers in their abilities to augment metaverse system adoption percentages in their own countries in the long term by focusing on specific cultural and social factors that aid or hinder the adoption phase.

1.10 Thesis Outline

An account of the chapters included in the thesis has been presented subsequently:

Chapter 1: This chapter gives an overview of the entire study to elucidate the research objectives and research questions to the readers. This Chapter entails the detailed account of research-problem definition and research motivations. At the end of this chapter, the research methodology is described.

Chapter 2: This chapter explores the evolution of education, carefully charting the transition from traditional teaching methods to the progressive integration of advanced technologies such as the Metaverse. This investigation seeks to showcase how these technological breakthroughs are transforming teaching and learning, providing fresh avenues for engagement and education in virtual spaces previously only imagined in science fiction.

Chapter 3: This study explored the students' attitude towards the use of the advanced metaverse system with the main objective to evaluate the metaverse system.

This study starts with the metaverse system definition and also sheds light on how this system is used in institutes for educational purpose. The study specifically focuses on the integration of metaverse system in the current educational system and technological resources and explains the proper application of this system. This thesis identifies the factors that shape students' attitudes with respect to metaverse system use and also evaluates each of them in detail. The survey also presented all the prospects and opportunities that were found to be offered by this system. In Chapter 3, the researcher proposes the research methodology that is appropriate for assessment of critical Technology Acceptance Model (TAM) constructs that influence the implementation of metaverse system. This chapter contains all the relevant information about the research model development. Moreover, this chapter explains the research hypotheses formulated to be evaluated during the study. The proposed hypotheses served as the theoretical base for the research. The chapter entails brief discussion of the research hypotheses and components of theoretical model.

Chapter 4: Provides a detailed description of the research methodology. It entails the descriptive account of research questions to be answered and evaluated during the study. The Chapter specifies the data collection sources and the respondents that participated in data collection. The structure of the survey handed out to students for data collection is also given in this chapter.

Chapter 5: The chapter presents the study findings based on the analysis of the surveys filled by students. The chapter discusses various techniques of data collection and analysis appropriate for the theoretical model. This chapter entails the final study model. At the end of this chapter, research hypotheses are validated.

Chapter 6: Entails the conclusion, limitations and recommendations and implications for future research.

1.11 Summary

There is a dearth of earlier research and studies that analyze metaverse systems adoption for scientific education at the elementary school level in the United Arab Emirates, as well as to adapt theoretical models to metaverse systems adoption, contends this study. This research will offer a conceptual model that is built on the sophisticated TAM and UTAUT model and is driven by an introspective study that was undertaken at the start of the research to comprehend and increase the adoption of metaverse systems. For that purpose, this chapter introduced the research topic as well as the context in which it was conducted. It also stated the research's aim, objectives, and significance. The following chapter goes into the systematic literature review that this research is premised upon.