NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF COMPUTER INFORMATION SYSTEM

MULTI-CRITERIA DECISION APPROACH FOR EVALUATION FACTORS AFFECTING MOBILE LEARNING APPLICATION ADOPTION

M.Sc. THESIS

FULBERT MILRICH KIMINOU NSIMBA

Nicosia

June, 2024

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M.Sc. THESIS

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Nicosia

June, 2024

Approval

We certify that we have read the thesis submitted by FULBERT MILRICH KIMINOU NSIMBA titled **"MULTI-CRITERIA DECISION APPROACH FOR EVALUATION FACTORS AFFECTING MOBILE LEARNING APPLICATION ADOPTION"** and that in our combined opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Computer Information Systems.

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Declaration

I declare that all information, documents, analysis, and results in this study have been collected and presented according to the academic rules and ethical guidelines of the Institute of Graduate Studies, Near East University. As required by these rules and conduct, I also declare that I have fully cited and referenced information and data not original to this study.

Fulbert Milrich Kiminou Nsimba

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Acknowledgments

I want to express my sincere appreciation to my supervisor, Assoc. Prof. Dr. Seren Başaran. Thank you for your constant support, guidance, and for equipping me with the necessary skills and research tools to complete my thesis within the given time frame. I want to thank my dear parents, André Nsimba and Marie Claire Louezie, for always being there for me and my big sisters Sorine Matondo, Rondelvie Mengue, and Merveille Mambimame. Andrea Bavouidi and Sorelle Nkembo, thank you for supporting me to this day. In addition, I am grateful to Prof. Dr. Nadire Çavuş for helping me through my academic journey, Prof. Dr. Fezile Ozdamli for helping me publish my first paper, and to the Department of Computer Information Systems. I am grateful for this great experience. Words are inadequate to convey how grateful and appreciative I am of you. Lastly, I would also like to thank Ronald Richar Oduke, Khaldoon Arshed, Zainab Deen, Francine Niyomwu, Josue Matondo Jeannet Gonda, Theresa Oldie, Mr. Patrick for their support, including my friends and roommates who took their time to share with me their knowledge.

Fulbert Milrich Kiminou Nsimba

Abstract

MULTI-CRITERIA DECISION APPROACH FOR EVALUATION FACTORS AFFECTING MOBILE LEARNING APPLICATION ADOPTION

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MA/PhD, Department of Computer Information Systems

Thesis Supervisor: Assoc. Prof. Dr. SEREN BAŞARAN

June, 2024, (81) pages

There is currently an abundance of mobile learning apps. However, little is known about what factors influence mobile learning apps adoption and their importance. This study first aims to identify critical factors that play an influential role in adopting mobile learning apps. For this purpose, a systematic literature review was performed from SWOT studies to identify those criteria. The four criteria of each dimension were selected, and then the fuzzy AHP method was applied to rank the criteria globally and locally. Therefore, this study investigates factors affecting mobile learning application adoption. Based on the area of study and the number of participants involved. This research investigated certain aspects affecting the adoption of mobile learning applications using a quantitative approach to collect the data among 25 students who received the email questionnaire survey. The main factors to investigate the adoption of mobile learning were divided into four categories: Strengths of mobile learning, Weaknesses of mobile learning, Opportunities of mobile learning, and Threats of mobile learning. The results indicated that the strengths of mobile learning (w= 0.36) and opportunities of mobile learning (w=0.26) have more impact on adopting mobile learning applications than the weaknesses (w=0.24) and threats of mobile learning (w=0.17). In addition, based on the rankings, mobile learning can be considered the most reliable and safest tool for improving the development and implementation of mobile learning applications through a comprehensive list of the prioritized factors that impact their adoption. No studies in the literature have investigated strengths, weaknesses, opportunities, or threats in adopting mobile learning applications and applied multicriteria decision-making in the design phase, making this study unique. Researchers should keep looking into mobile learning apps in the future to see how they affect long-term adoption in various educational settings.

Key Words: adoption factors, fuzzy AHP, mobile learning applications, multi-criteria decision-making, TOPSIS

Özet

MOBİL ÖĞRENME UYGULAMASINI ETKİLEYEN FAKTÖRLERİN DEĞERLENDİRİLMESİNDE ÇOK KRİTERLİ KARAR YAKLAŞIMI

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Haziran, 2024, (81) sayfa

Şu anda çok sayıda mobil öğrenme uygulaması var. Ancak mobil öğrenme uygulamalarının benimsenmesini hangi faktörlerin etkilediği ve bunların önemi hakkında çok az şey biliniyor. Bu çalışma öncelikle mobil öğrenme uygulamalarının benimsenmesinde etkili rol oynayan kritik faktörleri belirlemeyi amaçlamaktadır. Bu amaçla bu kriterleri belirlemek için SWOT çalışmalarından sistematik bir literatür taraması yapılmıştır. Her bir boyuta ait dört kriter seçilmiş ve daha sonra kriterlerin küresel ve yerel olarak sıralanması için bulanık AHP yöntemi uygulanmıştır. Bu nedenle bu çalışmada mobil öğrenme uygulamasının benimsenmesini etkileyen faktörler araştırılmaktadır. Çalışma alanına ve katılan katılımcı sayısına göre. Bu araştırma, e-posta anket anketini alan 25 öğrenci arasında veri toplamak için niceliksel bir yaklaşım kullanarak mobil öğrenme uygulamalarının benimsenmesini etkileyen belirli yönleri araştırdı. Mobil öğrenmenin benimsenmesini araştıran ana faktörler dört kategoriye ayrıldı: Mobil öğrenmenin güçlü yönleri, Mobil öğrenmenin zayıf yönleri, Mobil öğrenmenin fırsatları ve Mobil öğrenmenin Tehditleri. Sonuçlar, mobil öğrenmenin güçlü yönlerinin (w=0,36) ve mobil öğrenme fırsatlarının (w=0,26), mobil öğrenme uygulamalarının benimsenmesinde mobil öğrenmenin zayıf yönlerine (w=0,24) ve tehditlerine (w=0,17) göre daha fazla etkiye sahip olduğunu göstermiştir. . Buna ek olarak, sıralamalara göre mobil öğrenme, mobil öğrenme uygulamalarının benimsenmesini etkileyen öncelikli faktörlerin kapsamlı bir listesi aracılığıyla, mobil öğrenme uygulamalarının geliştirilmesini ve uygulanmasını iyileştirmek için en güvenilir ve en emniyetli araç olarak kabul edilebilir. Literatürde mobil öğrenme uygulamalarının benimsenmesinde ve tasarım aşamasında uygulanan çok kriterli karar vermede güçlü yönleri, zayıf yönleri, fırsatları veya tehditleri araştıran hiçbir çalışma bu çalışmayı benzersiz kılmaktadır. Araştırmacılar, çeşitli eğitim ortamlarında uzun vadeli benimsenmeyi nasıl etkilediklerini görmek için gelecekte mobil öğrenme uygulamalarına bakmaya devam etmelidir.

Anahtar Kelimeler: benimsenme faktörleri, bulanık AHP, mobil öğrenme uygulamaları, çok kriterli karar verme, TOPSIS

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List of Abbreviations

AHP:	Analytics Hierarchy Process
AI:	Artificial Intelligent
AR:	Augmented Reality
FAHP:	Fuzzy Analytics Hierarchy Process.
IOS:	iPhone Operating System
MCDM:	Multi-Criteria Decision Making
MDCA:	Multi-Criteria Decision Approach
MNE:	Ministry of National Education
OML:	Opportunities for Mobile Learning
SML:	Strengths of Mobile Learning
SWOT:	Strengths, Weaknesses, Opportunities, Threats
TML:	Threats of Mobile Learning
TOPSIS:	Technique for Order of Preference by Similarity to Ideal Solution
TRNC:	Turkish Republic of North Cyprus
WML:	Weaknesses of Mobile Learning

CHAPTER 1
INTRODUCTION

This chapter provides a comprehensive overview of mobile learning applications' importance in the digital era. It also discusses the factors influencing their adoption using the Fuzzy AHP method, particularly focusing on a SWOT analysis framework. This section explains the aim of the research, study goals, importance, and constraints.

1.1 Introduction

Mobile learning, in which people use their phones to learn at any time and place, has become an important digital education tool. (Saienko, 2020). According to (Adzifome & Nixon Saba, 2023) the use of mobile learning apps in schools is affected by many things, such as technical, pedagogical, organizational, and personal factors. A multi-criteria decision-making method is beneficial for figuring out this complicated world and making smart choices about using mobile learning apps. Mobile learning is also a dynamic way of teaching that is made possible by the growing popularity of mobile devices. It is a big change from traditional ways of teaching because it lets students do educational activities whenever and wherever they want (Mohiuddin & Khalid, 2021) . Rapid technological changes have fueled this change by making it possible to make mobile learning apps that give students personalized, easy-to-access, and engaging learning experiences (Swanson, 2020) . In this era of mobile technologies, mobile learning tools such as apps are pervasively available. Higher education institution educators and students use mobile learning apps frequently. Thus, 42matters provides statistics on learning applications in Google Play and IOS. The educational content provided by Google Play is 364,127 free applications and 12,566 paid applications. On the other hand, IOS provides educational content of 165,114 free applications and 17,523 paid applications. There are many studies that look into how people use mobile learning apps, but not many look at how people adopt these apps, especially from a SWOT analysis (Saienko, 2020). Students who use mobile learning apps make their decisions by looking at the reasons. Adzifome and Nixon Saba (2023) say that a critical part of this change is the common use of mobile learning apps, which make learning more flexible, accessible, and personalized. However, many things affect how well these apps are used, such as their strengths, weaknesses, opportunities, and threats (SWOT). Understanding and judging these factors are crucial for making wise choices and using effective tactics (Klimova, 2019).

Experts have used multi-criteria decision approaches to find and evaluate the most important factors when looking at what makes people use mobile learning apps. For instance, (Tripathi & Ashutosh Kumar, 2022) AHP was used to identify the elements that impact using mobile learning devices in higher universities, focusing on the importance of utility, connectivity, and perceived value. (Li & Yanjiao, 2020) It also looks at the most important reasons mobile learning is used in business training. They said having good information, keeping students interested, and offering good professional help was very important. It also involves a considerable amount of empirical work that tends not only to establish which aspects influence the usage of mobile learning apps but also how they interact with each other to investigate why students use such apps. Such individuals may carry out a multiple-criteria decision-making process to scrutinize these facets and place them in a descending order based on priority. This could help speed up adoption and mobilize learning apps to be a better fit. Furthermore, the research method that has been used in this study is one of the most efficient and significant tools put forward by. (Lotfi & Farhad, 2020). In order to enhance this work, the materials that I introduced in this paper were analyzed and examined by using the analysis and Fuzzy AHP methods. It is also possible to utilize fuzzy and machine learning to review and process the received data that was collected. (Li & Yanjiao, 2020).

The fuzzy Analytic Hierarchy Process (Fuzzy AHP) is based on the standard Analytic Hierarchy Process (AHP), Which was first introduced by (Lotfi & Farhad, 2020). In Fuzzy AHP, words like " Slightly more important," moderately more important, " and strongly more important" are used to describe how important factors and choices are in comparison to each other (Li & Yanjiao, 2020). This kind of fuzzy thinking helps people make better choices when they do not know everything or have only unclear knowledge. With the Fuzzy AHP method, people who make decisions can use their own tastes and judgments, which are not always right. Because of this, it works great when there is a lot of confusion and doubt. Engineers, managers, and people who study the environment have used this method to help people decide what to do when they do not know what to do (Tripathi & Ashutosh Kumar, 2022).

This study mainly uses a systematic review of SWOT-related studies on mobile learning apps. Second, the set of factors that were extracted was used as conditions for entry. After that, a limit was set to keep the standards given in the sources. For each SWOT dimension, four factors from the sources met the limit. Finally, these factors were ranked generally and within each dimension using the FAHP method to find the factors that had the most and least impact on the use of mobile learning apps.

1.2 Statement of the Problem

Mobile learning apps are becoming increasingly popular in higher education, making it more important to understand what makes students use them. There are a lot of studies on how to use mobile learning apps and how well they work, but not many look at the unique factors that make students want to use them. The problem is identifying those factors from literature review studies related to SWOT and using those factors as criteria for evaluating multiple DMs that use mobile learning apps to obtain a global and interdimensional ranking of the factors concerning their importance level.

1.3 Purpose of the Study

This study examines various factors influencing the number of people using mobile learning applications. Applies the multi-criteria decision-making (MCDM) method to attempt to identify these factors and rank them by their significance levels. The main purpose of this study is to establish comprehensive details regarding the intricate processes individuals undertake to embrace mobile learning apps. This research will increase our understanding of the strategies and plans that higher education institutions can use to inform the best choices and incorporate mobile learning technology into their lesson delivery.

1.4 Significance of the study

No studies in the literature have investigated strengths, weaknesses, opportunities, or threats in adopting mobile learning applications and applied multicriteria decision-making in the design phase; this is what makes this study unique in its kind.

1.5 Limitations

- **Data collection:**

  The limitation of this research is related to the data-collecting procedure among undergraduate students at the Faculty of Economics and Administrative Sciences at Near East University. Among the group of 25 students who were sent the survey via email, only 14 provided correct responses. In contrast, the remaining two did not provide satisfactory answers, and the others just copied and pasted other students' surveys and then changed their names. Due to these limitations, we were obliged to resend it to the 11 students to fill out correctly and send it back to us with corrections.
- **Time frame of studies:**

  The SWOT analysis for mobile learning apps only considered articles from 2019 to 2023. This limited time frame may have led to a narrow perspective, possibly overlooking valuable insights from earlier studies. Addressing these issues is important to ensure accurate and comprehensive results and to guide future research in the rapidly evolving field of mobile learning apps.
- **Decision Makers and Objectivity:**

  The fact that decision-makers participated in the study may have made the review process more subjective. However, it is very important to ensure that decision-makers (DMs) are reasonable for the integrity and veracity of the study results.
- **Methodological Constraints:**

  While the fuzzy AHP method and SWOT analysis are used effectively, the reliance on a specific set of methodologies may have limited the exploration of alternative approaches to evaluating factors affecting the adoption of mobile learning apps.

CHAPTER 2
LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This chapter provides information about the literature review of previously published studies; it discusses the benefits and advantages of these apps, emphasizing the importance of conducting a SWOT analysis to evaluate their effectiveness. The theoretical framework section outlines the study's goal to enhance the effective use of mobile learning applications in educational settings. The study will use the FAHP method and input from higher education students to identify critical factors influencing the use of mobile learning apps.

2.1 Literature Review

In the past few years, more and more schools have started using mobile learning apps (apps) to change how students access and interact with educational material. It is becoming more important to read total reviews of mobile learning apps as the world of mobile technology changes even faster. What is the SWOT analysis? This is a type of analysis tool that is commonly used and understood in business and management. Right now, it’s also being used for mobile lesson plans. This review of the literature tries to show all the studies that have been carried out on SWOT analysis for mobile learning apps. It’s mostly about these apps' strengths, weaknesses, opportunities, and threats (Moya & Sofia, 2023). Mobile learning apps have been looked into a great deal because they can make a big difference in how we learn. Interestingly, several scholars have identified several advantages of employing the mobile learning apps in the higher universities (Criollo-C & Santiago, 2021).

Several studies have examined what makes people want to use mobile learning apps. Some of the most common factors are technological factors like how easy it is to use, how well it works with other devices, and how well it functions; individual factors like motivation, how useful something seems, and self-efficacy. And contextual factors like institutional support, social influence, and cultural attitudes (Moya & Sofia, 2023). Technological factors like the user interface's design and the system's dependability are very important in ensuring that users can easily find their way around and use the apps effectively. How ready and sure of themselves people are to use new tools for learning depends on things like their drive and self-efficacy. There are also a lot of outside factors that affect the adoption process, such as help from schools and the effect of friends and society (Husnita & Liza, 2023). However, the relative value of these factors often changes depending on the user group and the learning environment. This variety shows the importance of a complex approach to understanding and encouraging people to use mobile learning.

SWOT analysis is a tool for strategic planning that helps you figure out what factors, inside and outside your organization, might affect the success of a project or business (Lazaro & Gizeh Rangel de, 2023) . This tool helps you understand the Strengths and weaknesses of a technology (internal factors) and the opportunities and threats it faces (external factors) regarding educational technology. This approach provides an all-round view of all that can influence the effectiveness and the extent of utilization of education-related instruments, such as mobile learning applications (Parnrod, 2020). An example of a strength could be that business Facebook applications are mobile learning apps, thus inherently adaptive and interactive. In this vein, a weakness might include technologically related issues such as software glitches and the compatibility of devices. Opportunities could be improved technology and all people transitioning to digital learning while threats could be arising from other factors such as data privacy and the digital divide (Díaz-Sainz & Guillermo, 2021).

Researchers have identified factors that influence mobile learning app user engagement in various studies that applied SWOT analysis. These apps are fully flexible and created interactively, allowing individual learning that can also be considered a strength usually (Kacetl & Jaroslav, 2019) . For this reason, current mobile learning apps benefit everybody, from elementary and secondary students to adults who would like to expand their knowledge daily throughout their lives. The weaknesses, for instance, may be caused by technological limitations, users' disagreement, and low-quality material use (Kacetl & Jaroslav, 2019) . Technical problems, like software bugs or connection issues, can make learning harder. User disagreement may come from not knowing how to use the technology or not believing that it works. Lifelong learning, flexibility, and working with other teaching tools are opportunities (Li & Yanjiao, 2020) . Mobile learning has many growth possibilities because learning programs can be made bigger and connected to other digital tools and platforms. Threats include worries about data protection, the digital gap, and how quickly technology changes, which could make apps useless (Mohiuddin & Khalid, 2021). Because learning apps can collect so much personal information, data privacy problems are especially troubling. Also, the digital gap still makes it hard for everyone to access mobile learning.

To determine how useful the factors found are in real life, it is important to consider the opinions of decision-makers who use mobile learning apps. These people, like teachers, students, managers, and lawmakers, give us helpful information about how and what problems mobile learning tools face in the real world (Parnrod, 2020). Feedback and experiences can raise real issues that are unclear from theory studies. For example, they may show that teachers need more training or that mobile learning needs to be added to current lessons. By examining what they have to say, we can get a better idea of what helps or hurts the use of mobile learning apps (Criollo-C & Santiago, 2021). This information can help people develop ways to improve mobile learning options and increase their use.

Even though there is a lot of study on mobile learning apps and how they are used, there are still some gaps. First, there are few comprehensive investigations that look into the SWOT analysis and the factors that make people want to use mobile learning apps. A lot of the studies that have already been done on mobile learning only look at one part of it. They do not fully picture the strengths, weaknesses, opportunities, and threats. Second, it is not clear how important these factors are compared to each other, especially when looking at it from the point of view of multiple decision-makers. Most studies only look at one group's point of view, like that of students or teachers, instead of including the points of view of many parties. Lastly, these factors need to be ranked on a global and inter-dimensional scale so that the creation and use of mobile learning tools can be better guided (Adzifome & Nixon Saba, 2023). This ranking could make it easy to decide which mobile learning apps to work on first and how to spend resources and time on them. This study tries to fill in these gaps to get a full picture of the factors that affect the use of mobile learning apps and give helpful advice to people who work with educational technology. This general method can help develop mobile learning solutions that are more useful, easy to use, and widely accepted, meeting the needs of educators and students.

2.2 Theoretical Framework

This study's theoretical framework offers an organized foundation for applying multi-criteria decision-making (MCDM) technique to analyze the factors affecting mobile learning application adoption through SWOT studies. The foundation of this framework is a knowledge of the strengths weaknesses opportunities and threats of mobile learning applications. The framework directs the entire research process, including the process of extracting criteria by conducting a systematic literature review.

2.2.1 Systematic Literature Review Steps for Extraction Criteria

Step 1: Identification of Research Topics

The systematic literature review started by identifying the main areas of interest: Mobile Learning Applications. The review aimed to undertake a SWOT analysis of educational mobile learning applications.

Step 2: Formulating Research Questions

Based on the aim to undertake a SWOT analysis of educational mobile learning applications, four primary research questions were formulated:

1. What strengths distinguish mobile learning applications?
2. What weaknesses are associated with mobile learning applications?
3. What opportunities exist for mobile learning applications?
4. What are the threats of mobile learning applications?

Step 3: Designing the Search Strategy

Using the PRISMA approach, a systematic search was conducted across the Google Scholar database for literature published between 2013 and 2023. The search keywords included terms related to digital education, educational Technology, E-learning, learning platforms, mobile learning, and SWOT Analysis.

Step 4: Applying Inclusion and Exclusion Criteria

The selection criteria ensured that only relevant, high-quality studies were included:

- **Inclusion:** Articles in English, open access articles, Articles published between (2019 and 2023), Journal articles relevant to the research topics and keywords.

- **Exclusion:** Non-English articles, non-open access articles, conference procedure.

Step 5: Screening and Selecting Studies

The Google Scholar database gathered 5394 articles, with 4 duplicates removed by hand, 3080 published before the desired timeline, 1056 omitted due to unavailability, and 190 omitted due to lack of significant keywords. After a merged list, 87 studies were selected for inclusion and exclusion criteria. Independent examination ensured relevance to keywords, research objectives, and subject matter. Only 17 studies persisted as primary studies for review.

Step 6: Data Extraction

Detailed data extraction from the selected studies focused on:

SWOT Analysis: Strengths (e.g., flexibility, engagement), Weaknesses (e.g., technical limitations, connectivity issues), Opportunities (e.g., personalized learning, continuous learning), and Threats (e.g., security and privacy concerns, digital divide).

Data Extraction

Table 1.

Data extraction

Data Item	**Description**
Domain type	The subject area of the document entails
Strength	Tangible benefits that are visible at the moment
Weakness	Current shortcomings
Opportunities	Future possibilities that are of a positive nature
Threats	Future possibilities of negative nature
Sources	The references of the documents

Table 1 presents the data extraction of the systematic literature reviw

Step 7: Criteria for Evaluation

The studies were categorized according to research themes related to the SWOT analysis of mobile learning applications. These criteria were defined and used as the basis of the SWOT analysis: They include:

- **Strengths of mobile learning**

- **Provide flexibility in learning:** Mobile learning applications allow students to access educational resources from anywhere, at any time (Díaz-Sainz & Guillermo, 2021).
- **Engage students in learning:** Mobile applications provide interaction, feedback, and motivation for students, leading to improved learning outcomes and knowledge retention (Lin & Chuanhong, 2023).
- **Interactive and helpful in learning:** Mobile learning allows for bidirectional and interactive communication, personalized learning experiences, and flexibility in learning (Moya & Camacho, 2021).
- **Facilitate access across devices:** Mobile applications allow easy access to learning materials, enhancing the learning experience anytime, anywhere(Klimova, 2019).

• **Weaknesses of mobile learning**

- **Lack of support and training:** Educators may require training to integrate mobile learning applications into their teaching practices effectively (Saienko, 2020).
- **Distract student's studies:** Mobile devices can be sources of distractions, potentially leading to reduced focus and productivity during learning activities (Parnrod, 2020).
- **Issues related to device hardware**: Usability challenges related to screen size and battery life of mobile devices (Mohiuddin & Khalid, 2021).
- **Require stable internet connectivity:** Reliance on internet connectivity for accessing content and resources can be a limitation, especially in areas with poor network coverage (Nugroho & Wilujeng, 2023).
- **Consider economic and policy implications:** Financial constraints and institutional policies may pose barriers to the adoption of mobile learning applications (Swanson, 2020)
- **Adress the need for digital skills development:** Some students and educators may lack the necessary digital literacy skills to

effectively utilize mobile applications for learning purposes, potentially leading to disparities in access and usage (Syarifuddin, 2023).

- **Content and resources limitations:** Limited learning content and resources in traditional m-learning (Parnrod, 2020).

- **Opportunities of mobile learning**
  - **Tailor learning:** Mobile learning allows for personalized and adaptive learning experiences tailored to individual needs and preferences (Díaz-Sainz & Guillermo, 2021).
  - **Provide global accessibility:** Mobile learning can facilitate access to educational resources for learners in remote or underserved areas, contributing to the democratization of education (Owusu-ansah & Samuel, 2019)
  - **Facilitate interaction among learners:** Mobile applications can facilitate collaborative learning experiences, enabling students to interact and engage with peers and educators (Moya & Camacho, 2021)
  - **Promote continuous learning:** Mobile learning supports lifelong learning initiatives by enabling individuals to engage in educational activities beyond traditional classroom settings (Klimova, 2019)
  - **Integrate new technologies in learning:** Integration of emerging computing paradigms such as mobile edge, fog, AI, and 5G networks can enhance the performance and efficiency of mobile learning systems (Saienko, 2020)
  - **Increase learning engagement and motivation:** It provides opportunities for interactive and engaging learning experiences through multimedia content and interactive applications (Mohiuddin & Khalid, 2021)
- **Threats of mobile learning**
  - **Security and Privacy Concerns:** Mobile learning systems may face threats related to data security and privacy,

especially when dealing with sensitive learner information (Mohiuddin & Khalid, 2021).

- **Not ensure equitable access to digital resources:** Socioeconomic disparities in access to mobile devices and internet connectivity can exacerbate educational inequalities, limiting the reach of mobile learning initiatives (Swanson, 2020).
- **Barrier in teaching methods and strategies**: Adapting teaching methods and instructional design for effective mobile learning experiences may pose challenges for educators and instructional designers (Saienko, 2020).
- **Challenges with implementing and using technology for education:** Mobile devices' screen size, battery life, and input interfaces can hinder their practical use in educational settings (Criollo-C, S & Altamirano-Suarez, 2022).

This study, therefore, proposes an engagement framework that will seek to enhance the utilization of mobile learning applications so that they may be used continually and optimally in learning environments. In previous research on systematic literature review, researchers pointed out that the acceptance process is going to comprise four significant categories, each accompanied by sub-criteria (Parnrod, 2020). This research shall employ the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) approach and survey results and findings from higher learning education professional (Tripathi & Ashutosh Kumar, 2022) . This study used quantitative research to ascertain the factors affecting the adoption of mobile learning applications. It wants to give a full picture of these factors. It is essential to know that the Analytic Hierarchy Process is a technique used in Multiple Criteria Decision Analysis (MCDA). It involves transforming subjective evaluations and qualitative data into quantitative data using mathematical methods, and it uses the fuzzy method to represent uncertain and unspecified information.to calculate and judge situations more quantitatively (Lotfi & Farhad, 2020).

Figure 1 below represents all the criteria of mobile learning applications extracted from the systematic literature review regarding the SWOT analysis.

Figure 1

Essential and successful factors for Mobile learning applications Implementation

Figure 1 represents the global factors extracted in the systematic literature review.

After collecting all the criteria from the previous study of systematic literature review, an evaluation was made for each criterion linked to the research questionnaire using the Likert scale, from 0 to 3 (0 – not mentioned, 1 – Poorly presented, 2 – Fairly presented and 3 – Well presented). Criteria represented in five or more articles received a score of 3 on the Likert scale. those represented in four or three articles received a score of 2 on the Likert scale. Those represented in two or more articles received a score of 1 on the Likert scale. No criteria received a score of 0 since all of them were represented. Criteria that received scores of 2 or more were included. Those that received a score of 1 or less were excluded. Tables 1, 2, 3, and 4 represent the Likert scale of the criteria that were included and excluded regarding the Likert scale and the SWOT analysis.

Table 2

Likert Scale of Strengths Criteria

Criteria	Articles	Scale	Presentation

Provide flexibility in learning	5	3	Well presented
Engage students in learning	4	2	Fairly presented
Interactive and helpful in learning	4	2	Fairly presented
Facilitate access across devices and platforms	5	3	Well Presented

Table 2 above represents the Linkert scale of the sub-criteria of strengths in the mobile learning application.

Table 3

Likert Scale of Weaknesses Criteria

Criteria	Articles	Scale	Presentation
Lack of support and training	3	2	Fairly presented
Consider economic and policy implications	2	1	Poorly presented
Issues related to device hardware	4	2	Fairly presented
Require stable internet connectivity	3	2	Fairly presented
Distract students studies	3	2	Fairly presented
Address the need for digital skills development	1	1	Poorly presented
Content and resource limitations	2	1	Poorly presented

Table 3 above represents the Linkert scale of the sub-criteria of weaknesses in the mobile learning application.

Table 4

Likert Scale of Opportunities Criteria

Criteria	Articles	Scale	Presentation
Tailors learning experiences	4	2	Fairly presented
Facilitate interaction and collaboration among learners	3	2	Fairly presented
Provide global accessibility	2	1	Poorly presented
Promote continuous learning	3	3	Fairly presented
Integrate new technologies into learning	4	3	Fairly presented
Increase learner engagement and	2	1	Poorly presented

motivation

Table 4 (continued)

Table 4 (continued) above represents the Linkert scale of the sub-criteria of opportunities in the mobile learning application.

Table 5

Likert Scale of Threats Criteria

Criteria	Articles	Scale	Presentation
Security and privacy concerns	4	2	Fairly presented
Does not ensure equitable access to digital resources	3	2	Fairly presented
Barriers in teaching methods and strategies	4	2	Fairly presented
Challenges with implementing and using technology for education	4	2	Fairly presented

Table 5 above represents the Linkert scale of the threat sub-criteria in the mobile learning application.

Table 6

Likert Scale for all Criteria Included

Criteria	Articles	Scale	Presentation
Provide flexibility in learning	5	3	Well presented
Engage students in learning	4	2	Fairly presented
Interactive and helpful in learning	4	2	Fairly presented
Facilitate access across devices and platforms	5	3	Well Presented
Lack of support and training	3	2	Fairly presented
Issues related to device hardware	4	2	Fairly presented
Require stable internet connectivity	3	2	Fairly presented
Distract students' studies	3	2	Fairly presented

Table 6 (continued)

Tailors learning experiences	4	2	Fairly presented
Facilitate interaction and collaboration	3	2	Fairly presented

among learners			
Promote continuous learning	3	3	Fairly presented
Integrate new technologies into learning	4	3	Fairly presented
Security and privacy concerns	4	2	Fairly presented
Does not ensure equitable access to digital resources	3	2	Fairly presented
Barriers in teaching methods and strategies	4	2	Fairly presented
Challenges with implementing and using technology for education	4	2	Fairly presented

Table 6 represents all the 16 criteria included in the study. Our study looks into mobile learning apps, focusing on four crucial SWOT factors. On top of the plan, we look at Strengths, Weaknesses, Opportunities, and Threats. Figure 1 shows the global factors of mobile learning applications. We chose these factors through a questionnaire and by looking at previous research. The study shows how important it is for mobile learning systems to be designed with the user in mind and for users to be happy with their experiences. According to study results, the previous example shows the basic requirements for setting up a mobile learning application admission system (Husnita & Liza, 2023) . So, as shown in Figure 2, this study chose factors based on what was known from earlier research. Table 7 gives a full summary and review of all the criteria used in this research.

This study aims to discover what makes people feel good about using mobile learning apps. We will consider how to keep people's information safe and check that the app has accurate information. After this, people will feel safer using the app and more likely to trust it. However, we need excellent management for this workout. So, the factors that affect the strengths, weaknesses, opportunities, and threats associated with mobile learning are put together, which leads to the next part.

2.2.2 Strengths of Mobile Learning

Even though many studies have been done on mobile learning, more needs to be done to determine how well this technology works in decision-making systems and how that affects student satisfaction. To understand its strengths, you must look at many things, such as its ability to make learning more accessible and flexible. (Criollo-C & Santiago, 2021) . Sub-criteria such as providing flexibility in learning, engaging students effectively, offering interactive and helpful learning experiences, and facilitating access across different devices and platforms contribute to this assessment. The quality of the mobile learning system significantly influences the adoption of mobile learning technology.

2.2.3 Weaknesses of Mobile Learning

Many studies have examined mobile learning, but more is needed to determine how well it works for decision-making systems, which directly affect students' happiness. (Moya & Sofia, 2023). Users need to look at several things to understand its flaws. For example, it can have technology problems, be annoying, and only feature a certain amount of content. The following sub-factors are part of the research's weaknesses criteria: Lack of support and training, distracting student studies, Issues related to device hardware, and lack of stable internet connectivity. The adoption of mobile learning technology is directly impacted by the weaknesses of mobile learning.

2.2.4 Opportunities of Mobile Learning

People's opinions and decisions about mobile learning are significant for making the most of the chances that this technology of mobile learning apps offers. Authors (Swanson, Joan Ann, 2020) personal factors and how well the user understands a technology are essential to mobile learning technologies. This is similar to how students feel about and understand mobile learning systems, significantly affecting their use of educational technology. Privacy and trust affect people's attitudes toward mobile learning (Mohiuddin & Khalid, 2021). Accepting mobile learning options depends on the person and how well they fit in with the school system. Knowing how to use technology well makes the system work better. However, Opportunities for mobile learning have the following sub-criteria: Tailor learning experiences, facilitate interaction among learners, integrate new technology into learning, and promote continuous learning. The opportunities in mobile learning directly impact the adoption of mobile learning technology.

2.2.5 Threats of Mobile Learning

Some problems can come up with using mobile learning apps in schools. These problems can stop people from integrating and using these technologies effectively. One significant threat is privacy and security issues when sensitive educational information is collected and managed. Some writers, including (Lazaro & Gizeh Rangel de, 2023) , have discussed the risks of collecting and keeping personal data in mobile learning settings. Furthermore, unequal access to mobile phones and internet connections is a significant problem that makes it hard to adopt mobile learning programs reasonably (Mohiuddin & Khalid, 2021) Points out. This digital divide makes it harder for some student groups to get learning tools and for others to get the education they deserve. Also, problems with technology and teaching, like changing how you teach and deal with technical issues, can make it hard to use mobile learning apps effectively. (Husnita & Liza, 2023). To get clear of these threats, we need complete plans that put security first, fix problems with access, and help teachers deal with the challenges of both teaching and technology. Thus, the threats of mobile learning have the following sub-criteria: security and privacy concerns, not ensuring equitable access to digital resources, barriers in teaching methods and strategies, and challenges with implementing and using technology for education.

Figure 2

Proposed model of influential elements on the adoption of mobile learning apps.

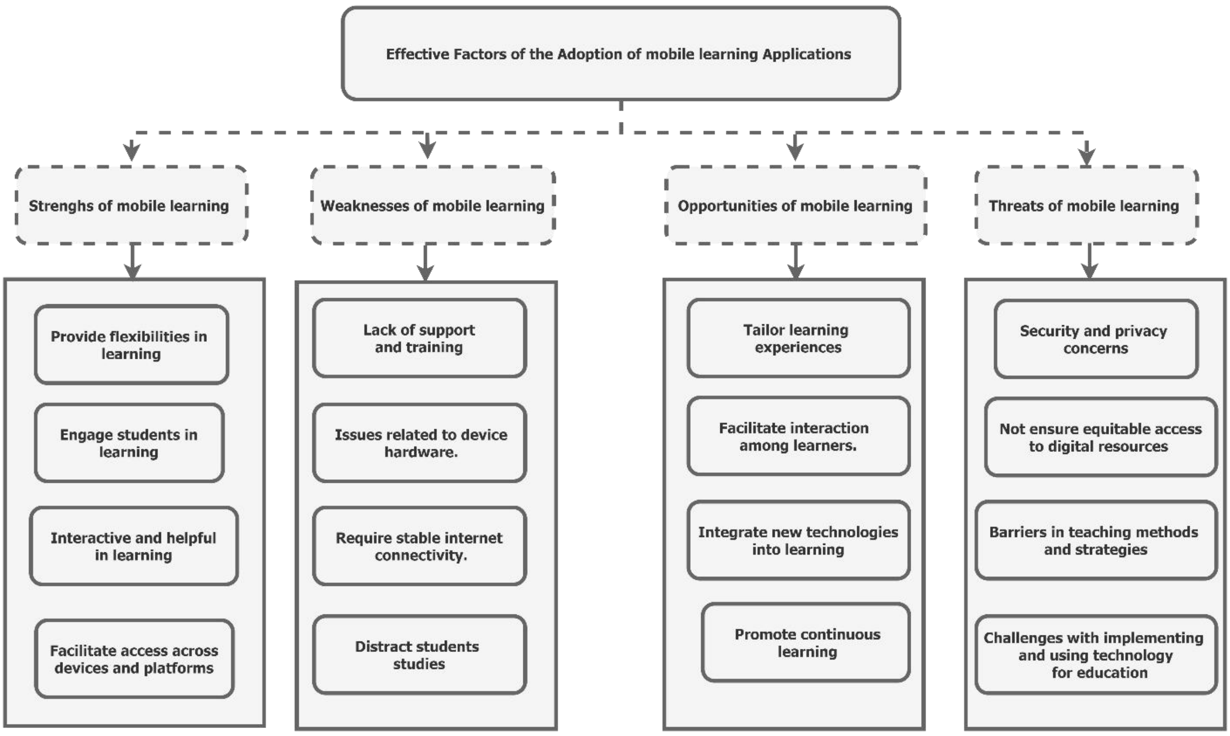


Figure 2 represents the model of influential factors on the use of mobile learning apps.

Table 7

Factors and Definitions in the Questionnaire Determination

Dimension	Criteria's code	Criteria	Description
Strengths of Mobile Learning (SML)	SML1	Provide flexibility in learning	Mobile learning applications allow students to access educational resources from anywhere, at any time. (Díaz-Sainz & Guillermo, 2021)
	SML2	Engage students in learning	Mobile learning applications engage students' motivation in their process of learning. (Tripathi & Ashutosh Kumar, 2022)
	SML3	Interactive and helpful in learning	Mobile applications provide interaction, feedback, and motivation for students, leading to improved learning outcomes and knowledge retention (Lin & Chuanhong, 2023)
	SML4	Facilitate access across devices and platforms	Mobile applications provide easy access to learning materials and resources anytime, anywhere, which can enhance the learning experience (Moya & Sofia, 2023)
Weaknesses of mobile learning (WML)	WML1	Lack of support and training	Inadequate support and required training to effectively integrate mobile learning applications into their teaching practices (Saienko, 2020) and (Kacetl & Jaroslav, 2019)
	WML2	Issues related to device hardware	Usability challenges related to mobile device screen size and battery life (Mohiuddin, Khalid, 2022)

Table 7 (Continued)

	WML3	Require stable internet connectivity	Reliance on internet connectivity for accessing content and resources can be a limitation, especially in areas with poor network coverage (Nugroho & Wilujeng, 2023)
	WML4	Distract students study	Mobile devices can be sources of distractions, potentially leading to reduced focus and productivity during learning activities (Nugroho & Wilujeng, 2023), (Li & Yanjiao, 2020) and (Nugroho & Wilujeng, 2023)
Opportunities of mobile learning (OML)	OML1	Tailor learning experiences	Mobile learning allows for personalized and adaptive learning experiences tailored to individual needs and preferences (Díaz-Sainz & Guillermo, 2021).
	OML2	Facilitate interaction among learners	Mobile applications can facilitate collaborative learning experiences, enabling students to interact and engage with peers and educators (Moya & Sofia, 2023)
	OML3	Integrate new technologies into learning.	Mobile learning can be used to adapt to technological developments in the world of education (Moya & Camacho, 2021).
	OML4	Promote continuous learning	Mobile learning supports lifelong learning initiatives by enabling individuals to engage in educational activities beyond traditional classroom settings (Klimova, 2019)

Table 7 (Continued)

Threats of mobile learning (TML)	TML1	Security and privacy concerns	Mobile learning platforms may be vulnerable to data breaches and privacy issues, raising concerns about the protection of sensitive educational information (Parnrod, 2020)
	TML2	Not ensuring equitable access to digital resources	Disparities in access to mobile devices and internet connectivity may widen the digital divide, limiting the reach of mobile learning initiatives (Adzifome & Nixon Saba, 2023)
	TML3	Barriers to teaching methods and strategies	Integrating mobile learning effectively into pedagogical practices requires training and support for educators, which may pose implementation challenges (Lin & Chuanhong, 2023).
	TML4	Challenges with implementing and using technology for education	Rapid advancements in technology may lead to the obsolescence of mobile learning platforms and content if not regularly updated and adapted to new technologies (Owusu-ansah & Samuel, 2019)

Table 7 represents the summary and review of all factors used in this study

2.2.5 Fuzzy Logic

Fuzzy logic is an approach to thinking about math and a type of logic that helps people make decisions and reason when they do not know what will happen in the future. There is also fuzzy logical thinking. Classical logic, called Boolean logic, can only take "true" or "false" values as inputs. Fuzzy logic, on the other hand, can take values that are neither true nor false. It is allowed to use values in the middle that show different levels of truth or places in a collection. With this in mind, it is helpful when working with unclear or correct data. When we talk about variables, verbal variables have amounts that are shown by language words or ideas, like "low," "medium," and "high." You do not use these phrases to talk about exact numbers. Instead, you talk about significant concepts or qualitative aspects of a system. This study adopts a triangular fuzzy membership function, as illustrated in the following figure.

Figure 3

Triangular Fuzzy Membership Function

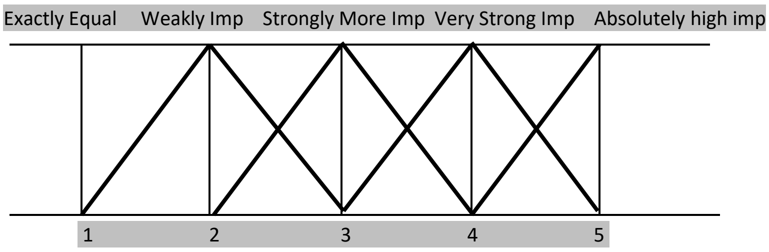


Table 8

Relationship Between Variable & Fuzzy Values as per Figure 3

Comparison (crisp)	Linguistic Variable	Fuzzy value
1	Exactly Equal	(1,1,3)
2	Weakly Important	(1,3,5)
3	Strongly More Important	(3,5,7)
4	Very Strongly Important	(5,7,9)
5	Absolutely High Importance	(7,9,11)

Table 8 represent the relationship between the variable and Fuzzy Value.

Table 9

Relationship Between Crisp Value & Inverse Fuzzy Value

Comparison (crisp)	**Fuzzy value (Inverse)**	**Fuzzy value**
1/1	$(1,1,3)^{-1}$	$(\frac{1}{3},\frac{1}{1},\frac{1}{1})$
1/2	$(1,3,5)^{-1}$	$(\frac{1}{5},\frac{1}{3},\frac{1}{1})$
1/3	$(3,5,7)^{-1}$	$(\frac{1}{7},\frac{1}{5},\frac{1}{3})$
1/4	$(5,7,9)^{-1}$	$(\frac{1}{9},\frac{1}{7},\frac{1}{5})$
1/5	$(7,9,11)^{-1}$	$(\frac{1}{11},\frac{1}{9},\frac{1}{7})$

Table 9 represent the relationship between Crisp Value and the Inverse Fuzzy Value.

2.2.6 Fuzzy AHP

The regular Analytic Hierarchy Process (AHP) is improved by the Fuzzy Analytic Hierarchy Process (Fuzzy AHP). The Fuzzy AHP adds fuzzy logic to the regular AHP to help people decide when they do not know what to do. AHP, which stands for "analytical hierarchy process," is a way to make choices by reviewing a list of options and ranking them based on several factors. In the 1970s, Thomas L. Saaty was the first to think of the idea. The fuzzy AHP method adds to the AHP by helping users make decisions based on untrue and unknown results. People might be confused when making decisions in the real world because they do not always have evident and correct numbers to compare. In fuzzy logic, vague words and phrases like "very important," "somewhat important," and "not important" are used to show these unclear results.

CHAPTER 3
METHODOLOGY

This chapter provides information about the Fuzzy AHP method, the research design, data collection and analysis, research procedures, and research schedules, as well as how the findings are analyzed.

3.1 Methodology

3.1.1 Research design

This study uses multi-criteria decision analysis to investigate the factors influencing the adoption of mobile learning applications in educational institutions. The research procedures include a planned method of obtaining criteria from a literature review, creating a questionnaire based on those criteria, giving the questionnaire to 25 students using mobile learning apps, collecting data, and using the Fuzzy Analytical Hierarchy Process (AHP) method to rank the criteria on a global and inter-dimensional scale. The questionnaire was developed based on the criteria collected from the systematic literature study related to the SWOT analysis of mobile learning applications to collect data. Students' opinions and experiences with utilizing mobile learning applications were collected via a questionnaire. Likert scale questions were used to evaluate the significance of every criterion in determining the adoption of mobile learning applications.

Figure 4

Flow diagram of entire steps of the study and for Conducting FAHP

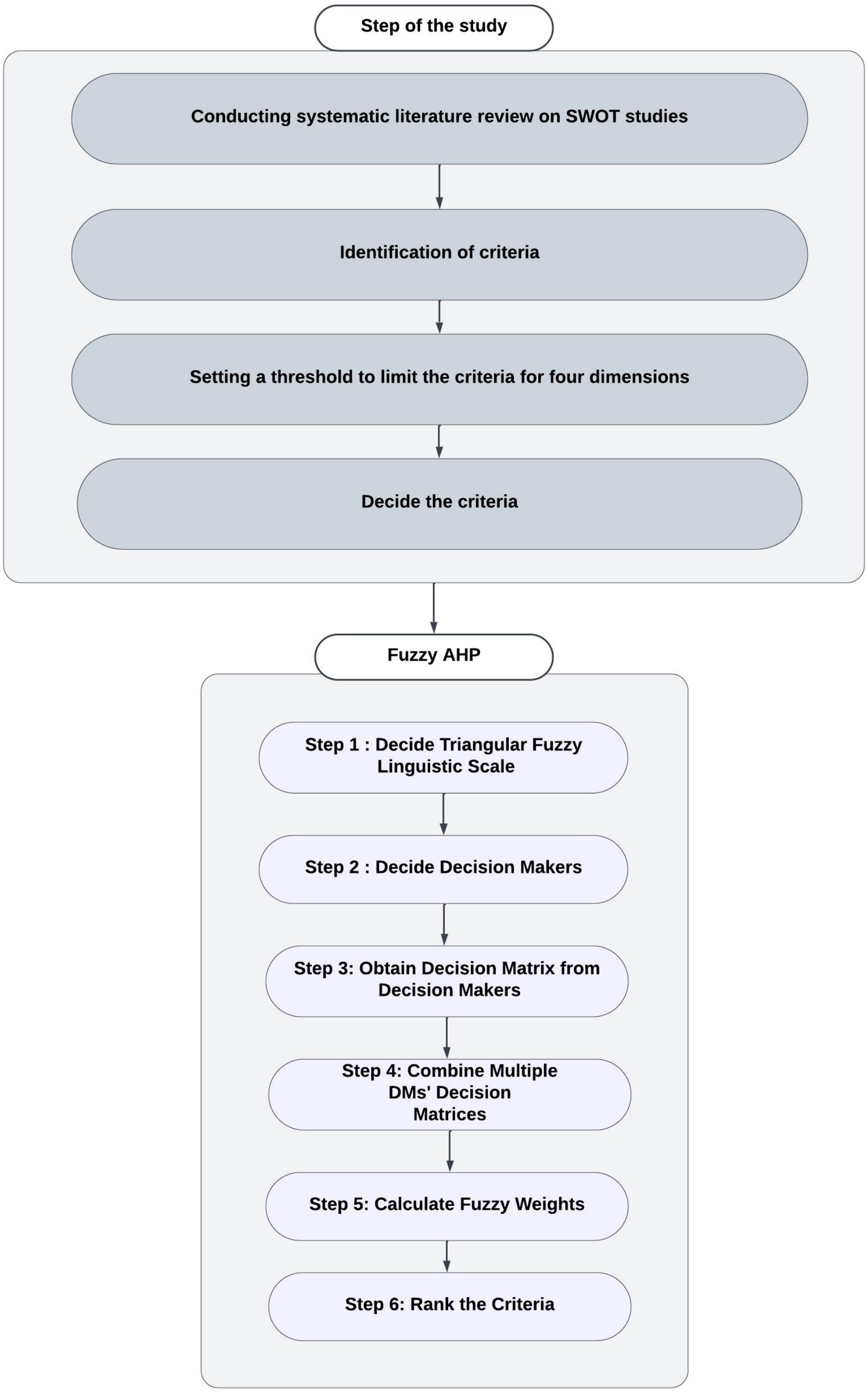


Figure 4 represents the flow diagram of the entire steps of the study and for Conducting FAHP

3.1.2 Participants

Twenty-five undergraduate students enrolled in the ethics course during the spring semester of 2023-2024 at Near East University in the Faculty of Economics and Administrative Sciences participated in the study. The participants were chosen because they actively use mobile learning apps and are familiar with using technology in the classroom. The evaluation was given to these students to get their comments and ideas on what makes people use mobile learning apps.

Table 10

Distribution of the Faculty of Education Students According to Demographic Variables

Field of the study	Number of students	Gender(M)	Gender(F)
Computer Information Systems	13	10	3
Management Information Systems	12	10	2
Total	25	20	5

Table 10 represents the demographic distribution of the surveyed students; 25 were surveyed, 20 were male, and five were female. 13 were from the field of Computer Information Systems, and 12 were from the field of Management Information Systems.

Figure 5

Student's Age by Range

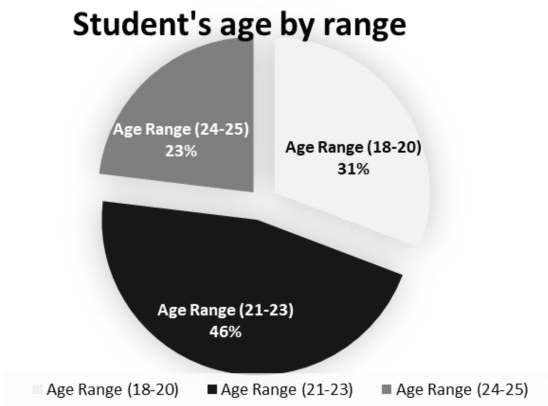


Figure 5 illustrates the ages of the students sample surveyed ranges: 23% of students were from the range (24-25), 31% were from the range (18-20), and 46 % were from the range (21-23).

Figure 6

Frequency Of Mobile Learning Use by Students

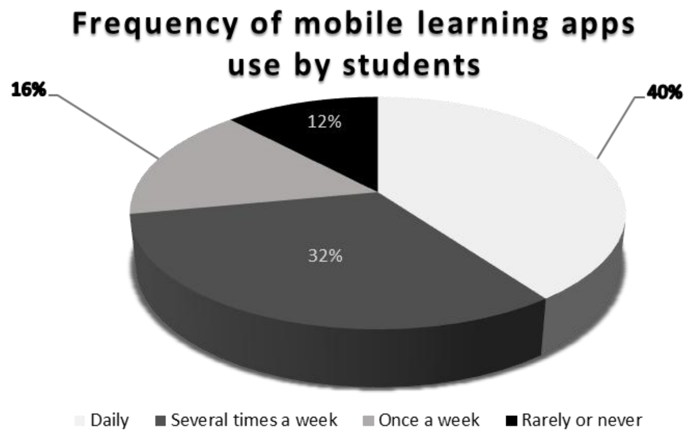


Figure 6 illustrates the number of times students use mobile learning apps: 12% use them rarely or never, 16% use them once a week, 32% use them several times a week, and 40 % use them daily.

3.1.3 The Fuzzy AHP Method

In 1980, Saaty created a new way to make decisions called AHP. It quickly became one of the most famous ways to make decisions. As you can see, this method breaks the problem down into smaller, easier-to-handle components. However, there are issues with the method because it uses the exact values given by the person choosing to show how they feel about the options by comparing them pair by pair. (Chang, 1996) This method was changed by suggesting a triangular fuzzy numbers system that uses the pair-wise comparison scale of FAHP. Also, the extent analysis method for synthetic extent estimates can compare two things simultaneously.

As a result, The FAHP technique is employed for the purpose of determining how important each factor is when making decisions. In the choice matrix, however, the pairwise comparisons comprise fuzzy numbers. The following steps were used to check the factors affecting mobile learning app use. Using the Chang (1996) method, each factor is chosen, and each goal goes through an extent analysis.

- Step5: Fuzzy AHP Method

- **Sub-step 1**: For the i^{th}object, the fuzzy synthetic is found by:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (1)$$

To derive $\sum_{j=1}^{m} M_{gi}^{j}$, The fuzzy addition operation of m extent analysis values for the particular matrix is performed such as:

$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right)$he To acquire $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]$, by performing the fuzzy addition operation of $M_{gi}^{j}(j = 1,2, \ldots,)$ such that (2)

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (3)$$

And $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$An be calculated by the inverse of Eq. (3), as follows:

(4)

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} u_i}\right)$$

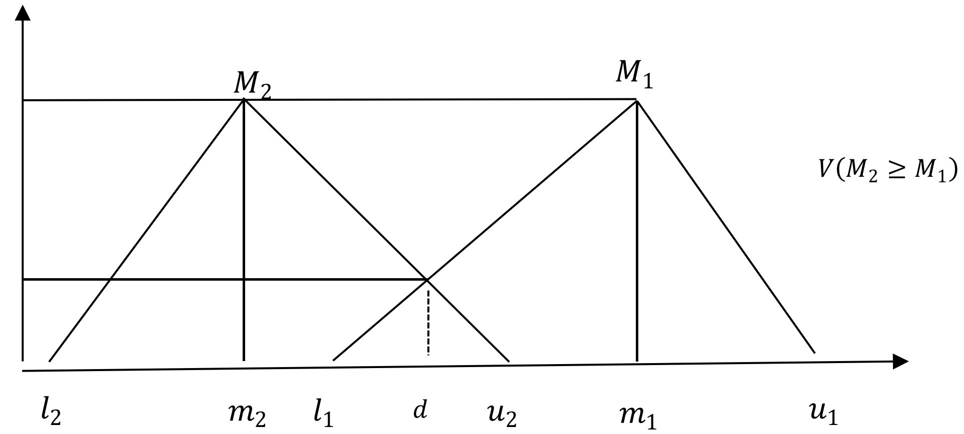
- **Sub-Step 2:** As $M_1 = (l_1, m_1, u_1)$, and $M_2 = (l_2, m_2, u_2)$Are two triangular fuzzy numbers, the degree of possibility of $M_2 \geq M_1$ is defined as

$V = (M_2 \geq M_1)$ =$\left[min\ (\mu_{M_1}(x), \mu_{M_2}(y))\right]$ (5)

Moreover, it can be equivalently expressed as follows:

$$V(M_1 \geq M_2) = hgt(M_1 \cap M_2) = \mu_{M_1}(d) = \begin{cases} 1 & if\ m_1 \geq m_2 \\ 0 & ; if\ l_2 \geq u_1 \\ \dfrac{(l_2 - u_1)}{(m_1 - u_1) - (m_2 - l_2)} & Otherwise \end{cases} \quad (6)$$

Where d, as shown in the figure below, is the highest intersection point D between $\mu(M_1)$ and $\mu(M_2)$ to compare $M_1 = (l_1, m_1, u_1)$, and $M_2 = (l_2, m_2, u_2)$, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$



Insertion between M1 and M2

The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i (i = 1,2, ..., k)$Numbers can be defined by

$$V(M \geq M_1, M_2, ..., M_k) = v[M \geq M_1 and\ M \geq M_2\ and\ M \geq M_k]$$

$$= minv\ M \geq M_1, i = 1,2, ..., k \quad (7)$$

- **Sub-Step 3:** Calculate the weight vector.

Assume that

d'(A_i) = $minV(S_i \geq S_k)\ for\ k = 1,2, ..., n; k \neq i$ Then, the weight vector is given by

$$W^{'} = (d'(A_1), d'(A^{'}_2, ..., d'(A_n))^T \quad (8)$$

Where A_i(i=1, 2, …., n) are n elements

- **Sub-Step 4:** Via normalization, the normalized weight vectors are

$$w = (d(A_1), d(A_2), ..., d(A_n))^T \quad (9)$$

Where w is a non-fuzzy number.

3.1.4 Data Collection and Analysis

This research seeks to determine the factors that impact the acceptance of mobile learning through the use of FAHP methods following an in-depth review, this research extracted some of the leading and influential factors and their underlying factors (Table 7). Quantitative data was collected from undergraduate students enrolled in an ethics course for the 2023-2024 spring term, an online E-mail questionnaire based on an AHP-pair comparison between the factors. A detailed questionnaire was distributed to undergraduate students to survey their mobile learning system experiences. Their responses were gathered according to a five-point Likert scale, as shown in (Table 10). The survey questionnaires were sent via E-mail to Near East University students who were offered 5 points extra in their final exam as a reward for participation. Most students surveyed belong to the Faculty of Economics and Administrative Sciences for convenience reasons. The department's students were interviewed due to their superior understanding of technological advancement, particularly in mobile learning applications.

3.1.5 Research Procedure

The study was conducted in the following steps chronologically:

1. A review of various literature was conducted based on the related subject area to investigate why, how, and what previous studies had found and identify study lapses. This provided a road map for the study.
2. The ethics committee accepted a research proposal for the study.
3. Based on the literature review results, a conceptual framework was developed for assessing the criteria of mobile learning applications using a SWOT analysis.
4. Later, a research model based on surveys was developed to investigate and rank the factors that affect the adoption of mobile learning using multicriteria decision-making techniques.
5. The selection and evaluation of 25 samples was conducted using FAHP methods.
6. Subsequently, a discussion of the result and recommendations was made.

3.1.6 Research Schedules

The research was completed in 16 weeks and five days, as depicted in Table 27. The Figure shows the study's Gant chart.

Table 11

Research schedules

Work done	Duration
Thesis approval and seeking approval………………………………………………	4 Weeks
Writings Thesis………………………………………………………………….........	6 Weeks
Data collection, selection, and evaluation………………………..…………………....	3 Weeks
Final thesis draft……………………………………………………………………..	2 Weeks
Reading, discussion, and correction based on the feedback of supervisor ……..	1 Week, 5 Ds
Total	16 Weeks and 5 Ds

Figure 7

Study Gant Chart

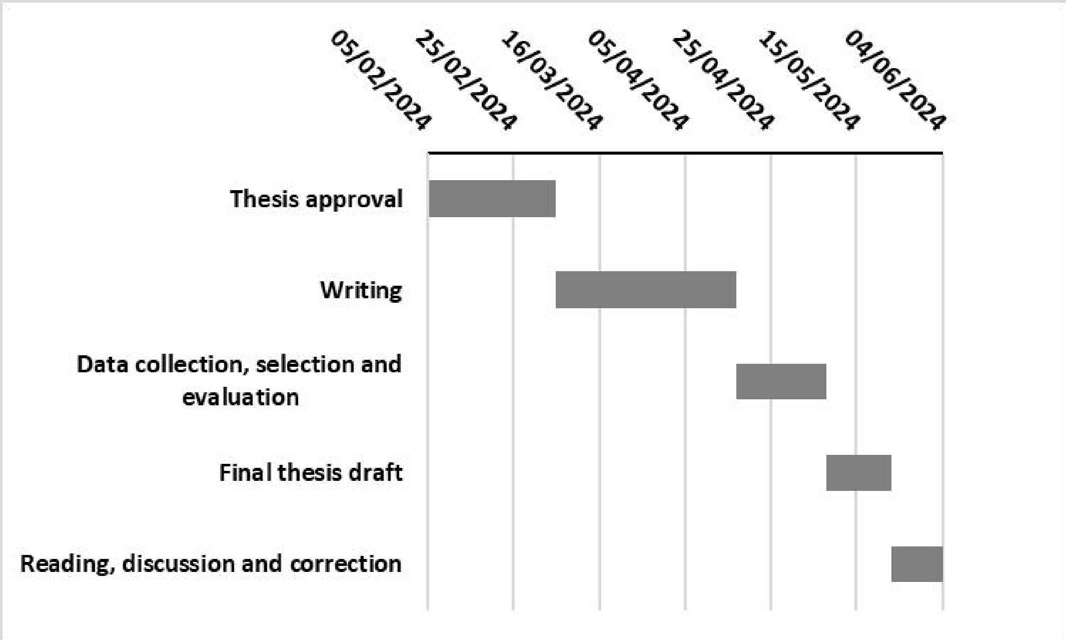


Figure 7 represents the Gant Chart of the study

CHAPTER 4
FINDINGS AND DISCUSSION

This chapter presents the findings and the discussion based on the collected data of a SWOT analysis of mobile learning applications using FAHP to evaluate the factors affecting their adoption using a multicriteria decision approach and rank them according to their importance as priorities.

4.1 Findings

- Step1: Deciding Triangular Fuzzy Linguistic Scale

Determine the triangular Fuzzy Numbers (TFNs) for linguistic terms:

Table 12

Triangular Fuzzy Linguistic Scale

Linguistic Variable	Fuzzy value	TFN^{-1}
Exactly Equal	(1,1,3)	(0.333,1.000,1.000)
Weakly Important	(1,3,5)	(0.200,0.333,1.000)
Strongly More Important	(3,5,7)	(1.143,0.200,0.333)
Very Strongly Important	(5,7,9)	(0.111,1.143,0.200)
Absolutely High Importance	(7,9,11)	(0.091,0.111,1.143)

Decide Decision Makers

Identifications of decision-makers: Each decision was made by 25 students who filled out the survey questionnaire—examples: 25 students as DM1, DM2, …, DM25.

- Step3: Obtain Decision Matrixes from Decision Makers

Create Decision Matrices: Each DM provides pairwise comparisons of the criteria using the linguistic variable in Step 1.

Decision matrix for DM1

Table 13 represents the Pairwise comparison matrix for the 1st Decision Makers of the Main Factors.

Table 13

Pairwise Comparison Matrix for the 1st Decision Makers of the Main Factors

	SML	WML	OML	TML

SML	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(5.000,7.000,9.000)	(3.000,5.000,7.000)
WML	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(5.000,7.000,9.000)
OML	(0.111,0.143,0.200)	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(3.000,5.000,7.000)
TML	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(1.000,1.000,1.000)

Table 14 represents the Pairwise comparison matrix of SML for 1st Decision Makers of the Sub Factors.

Table 14

Pairwise comparison matrix of SML for 1st Decision Makers of the Sub Factors

	SML1	**SML2**	**SML3**	**SML4**
SML1	(1.000,1.000,1.000)	(5.000,7.000,9.000)	(5.000,7.000,9.000)	(7.000,9.000,11.000)
SML2	(0.111,0.143,0.200)	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(3.000,5.000,7.000)
SML3	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
SML4	(0.091,0.111,0.143)	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 15 represents the Pairwise comparison matrix of SML for 1st Decision Makers of the Sub Factors.

Table 15

Pairwise comparison matrix of WML for 1st Decision Makers of the Sub Factors.

	WML1	**WML2**	**WML3**	**WML4**
WML1	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)
WML2	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(1.000,3.000,5.000)
WML3	(0.143,0.200,0.333)	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
WML4	(0.111,0.143,0.200)	(0.200,0.333,1.000)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 16 (continued) represents the Pairwise comparison matrix of OML for 1st Decision Makers of the Sub Factors.

Table 16

Pairwise comparison matrix of OML for 1st Decision Makers of the Sub Factors.

	OML1	OML2	OML3	OML4
OML1	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)	(5.000,7.000,9.000)
OML2	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(3.000,5.000,7.000)
OML3	(0.111,0.143,0.200)	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
OML4	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 17 represents the Pairwise comparison matrix of TML for 1st Decision Makers of the Sub Factors.

Table 17

Pairwise comparison matrix of TML for 1st Decision Makers of the Sub Factors.

	TML1	TML2	TML3	TML4
TML1	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(1.000,3.000,5.000)	(3.000,5.000,7.000)
TML2	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(5.000,7.000,9.000)	(5.000,7.000,9.000)
TML3	(0.200,0.333,1.000)	(0.111,0.143,0.200)	(1.000,1.000,1.000)	(3.000,5.000,7.000)
TML4	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(1.000,1.000,1.000)

Tables 13, 14, 15, 16, and 17 represent the pairwise comparison of the first Decision Makers of the Subfactors.

Table 18 represents the Pairwise comparison matrix for the 25^{TH} Decision Makers of the Main Factors.

Decision matrix for DM25

Table 18

Pairwise Comparison Matrix for the 25^{TH} Decision Makers of the Main Factors.

	SML	WML	OML	TML
SML	(1.000,1.000,1.000)	(7.000,9.000,11.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)
WML	(0.091,0.111,0.143)	(1.000,1.000,1.000)	(5.000,7.000,9.000)	(1.000,3.000,5.000)
OML	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
TML	(0.111,0.143,0.200)	(0.200,0.333,1.000)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 19 represents the Pairwise comparison matrix for the 25^{TH} Decision Makers of the Main Factors.

Table 19

Pairwise Comparison Matrix of SML for 25th Decision Makers of the Sub Factors.

	SML1	SML2	SML3	SML4
SML1	(1.000,1.000,1.000)	(7.000,9.000,11.000)	(3.000,5.000,7.000)	(3.000,5.000,7.000)
SML2	(0.091,0.111,0.143)	(1.000,1.000,1.000)	(7.000,9.000,11.000)	(1.000,3.000,5.000)
SML3	(0.143,0.200,0.333)	(0.091,0.111,0.143)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
SML4	(0.143,0.200,0.333)	(0.200,0.333,1.000)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 20 represents the Pairwise comparison matrix for the 25TH Decision Makers of the Sub Factors.

Table 20

Pairwise Comparison Matrix of WML for 25th Decision Makers of the Sub Factors.

	WML1	WML2	WML3	WML4
WML1	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(7.000,9.000,11.000)	(1.000,3.000,5.000)
WML2	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(3.000,5.000,7.000)
WML3	(0.091,0.111,0.143)	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(5.000,7.000,9.000)
WML4	(0.200,0.333,1.000)	(0.143,0.200,0.333)	(0.111,0.143,0.200)	(1.000,1.000,1.000)

Table 21 represents the Pairwise comparison matrix for the 25TH Decision Makers of the Sub Factors.

Table 21

Pairwise Comparison Matrix of OML for 25th Decision Makers of the Sub Factors.

	OML1	OML2	OML3	OML4
OML1	(1.000,1.000,1.000)	(1.000,3.000,5.000)	(7.000,9.000,11.000)	(1.000,1.000,3.000)
OML2	(0.200,0.333,1.000)	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)
OML3	(0.091,0.111,0.143)	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(3.000,5.000,7.000)
OML4	(0.333,1.000,1.000)	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(1.000,1.000,1.000)

Table 22 represents the Pairwise comparison matrix for the 25TH Decision Makers of the Sub Factors.

Table 22

	TML1	TML2	TML3	TML4
TML1	(1.000,1.000,1.000)	(3.000,5.000,7.000)	(1.000,3.000,5.000)	(5.000,7.000,9.000)
TML2	(0.143,0.200,0.333)	(1.000,1.000,1.000)	(7.000,9.000,11.000)	(3.000,5.000,7.000)
TML3	(0.200,0.333,1.000)	(0.091,0.111,0.143)	(1.000,1.000,1.000)	(1.000,3.000,5.000)
TML4	(0.111,0.143,0.200)	(0.143,0.200,0.333)	(0.200,0.333,1.000)	(1.000,1.000,1.000)

Pairwise Comparison Matrix of TML for 25th Decision Makers of the Sub Factors.

- Step4: Combine Multiple DMs' Decision Matrices

To combine the 25 decision-makers, we used the online software Fuzzy AHP Online, found in "**Online Output.**" The screenshots of the appendix show the expert status of the 25 students combined through this software. The following tables matrix represents the mean of all the 25 DMs combined.

Table 23

Pairwise Comparison Matrix for the 25 Decision Makers Combined of the Main Factors

	SML	WML	OML	TML
SML	(1.000,1.000,1.000)	(1.000,4.432,11.000)	(1.000,5.627,11.000)	(1.000,4.851,11.000)
WML	(0.091,0.226,1.000)	(1.000,1.000,1.000)	(1.000,2.983,9.000)	(1.000,4.197,11.000)
OML	(0.091,0.178,1.000)	(0.111,0.335,1.000)	(1.000,1.000,1.000)	(1.000,4.117,9.000)
TML	(0.091,0.206,1.000)	(0.091,0.238,1.000)	(0.111,0.243,1.000)	(1.000,1.000,1.000)

Table 24

Pairwise Comparison Matrix for the SML of 25 Decision Makers Combined of the Sub-Factors

	SML1	SML2	SML3	SML4
SML1	(1.000,1.000,1.000)	(1.000,4.875,11.000)	(1.000,5.540,11.000)	(1.000,5.198,11.000)
SML2	(0.091,0.205,1.000)	(1.000,1.000,1.000)	(1.000,4.383,11.000)	(1.000,4.564,11.000)
SML3	(0.091,0.181,1.000)	(0.091,0.228,1.000)	(1.000,1.000,1.000)	(1.000,4.609,9.000)
SML4	(0.091,0.192,1.000)	(0.091,0.219,1.000)	(0.111,0.217,1.000)	(1.000,1.000,1.000)

Table 25

Pairwise Comparison Matrix for the WML of 25 Decision Makers Combined of the Sub-Factors

	WML1	WML2	WML3	WML4
WML1	(1.000,1.000,1.000)	(1.000,3.529,9.000)	(1.000,4.751,11.000)	(1.000,3.980,11.000)
WML2	(0.111,0.283,1.000)	(1.000,1.000,1.000)	(1.000,4.187,11.000)	(1.000,4.126,11.000)
WML3	(0.091,0.210,1.000)	(0.091,0.239,1.000)	(1.000,1.000,1.000)	(1.000,4.318,11.000)
WML4	(0.091,0.251,1.000)	(0.091,0.242,1.000)	(0.091,0.232,1.000)	(1.000,1.000,1.000)

Table 26

Pairwise Comparison Matrix for the OML of 25 Decision Makers Combined of the

	OML1	OML2	OML3	OML4
OML1	(1.000,1.000,1.000)	(1.000,5.214,11.000)	(1.000,4.710,11.000)	(1.000,4.087,11.000)
OML2	(0.091,0.192,1.000)	(1.000,1.000,1.000)	(1.000,5.122,11.000)	(1.000,5.283,11.000)
OML3	(0.091,0.212,1.000)	(1.000,1.000,1.000)	(1.000,1.000,1.000)	(1.000,4.568,11.000)
OML4	(0.091,0.245,1.000)	(0.091,0.189,1.000)	(0.091,0.219,1.000)	(1.000,1.000,1.000)

Sub-Factors

Table 27

Pairwise Comparison Matrix for the TML of 25 Decision Makers Combined of the

	TML1	TML2	TML3	TML4
TML1	(1.000,1.000,1.000)	(1.000,3.656,11.000)	(1.000,4.258,11.000)	(1.000,4.432,11.000)
TML2	(0.091,0.274,1.000)	(1.000,1.000,1.000)	(1.000,4.206,11.000)	(1.000,4.445,11.000)
TML3	(0.091,0.235,1.000)	(0.091,0.238,1.000)	(1.000,1.000,1.000)	(1.000,4.428,11.000)
TML4	(0.091,0.226,1.000)	(0.091,0.225,1.000)	(0.091,0.226,1.000)	(1.000,1.000,1.000)

Sub-Factors

Table 23,24,25,26,27 above represents the DMs of 25 students combined.

4.1.1 Main factors of mobile learning applications

Using the online survey, this study evaluates the effectiveness and importance of the variable in promoting mobile learning adoption. This ranking shows the importance of the influencing factors in reaching this goal. The results of this ranking can serve as a guide for future researchers.

Table 28

	SML	WML	OML	TML
SML	(1.000,1.000,1.000)	(1.000,4.432,11.000)	(1.000,5.627,11.000)	(1.000,4.851,11.000)
WML	(0.091,0.226,1.000)	(1.000,1.000,1.000)	(1.000,2.983,9.000)	(1.000,4.197,11.000)
OML	(0.091,0.178,1.000)	(0.111,0.335,1.000)	(1.000,1.000,1.000)	(1.000,4.117,9.000)
TML	(0.091,0.206,1.000)	(0.091,0.238,1.000)	(0.111,0.243,1.000)	(1.000,1.000,1.000)

The Developed Fuzzy Matrix Of the Main Factors

A fuzzy evaluation matrix was developed as a hierarchy structure. Table 28 depicts the evaluation matrix according to the adopted method, FAHP.

Table 29

Main Factors	Sum of rows	Sum of columns
SML	(4.000,15.91,34.000)	(1.273,1.61,4.000)
WML	(3.091,8.406,22.000)	(2.202,6.005,14.000)
OML	(2.202,5.63,12.000)	(3.111,9.853,22.000)
TML	(1.293,1.687.4.000)	(4.000,18.165,32.000)
Sum of columns		(10.586,35.633,72.000)

The sum of rows and columns' main factors

Table 29 represent the sum of row and columns of the main factors. After creating the matrix for comparing pairs using fuzzy logic, FAHP determines the weight of each criterion. However, according to FAHP methodology, the synthesis extent values should be determined. By using the **Sub-step1** the synthesis extent values can be determined according to **Equation 1**. The following calculations show all the extent values.

$$Sc_1 = (4.000, 15.91, 34.000) \otimes (10.586,35.633,72.000)^{-1}$$
$$= (0.0555, 0.4464, 3.2117)$$

$$Sc_2 = (3.091,8.406,22.000) \otimes (10.586,35.633,72.000)^{-1}$$
$$= (0.0429, 0.2359, 2.0782)$$

$$Sc_3 = (2.202,5.63,12.000) \otimes (10.586,35.633,72.000)^{-1}$$
$$= (0.0305, 0.1579, 1.1335)$$

$$Sc_4 = (1.293,1.687.4.000) \otimes (10.586,35.633,72.000)^{-1}$$
$$= (0.0179, 0.0473, 0.3778)$$

Table 30

The result of the synthesis values of the main factor

Main Factors	Sci
SML	(0.0555,0.4464,3.2117)
WML	(0.0429,0.2359,2.0782)
OML	(0.0305,0.1579,1.1335)
TML	(0.0179,0.0473,0.3778)

Table 30 represents the synthesis values of the main factors.

By using **Sub-step2** the above synthesis value was used to make a comparison using **equation 6** to obtain the following results:

$V(Sc_1 \geq Sc_2) = 1, V(Sc_1 \geq Sc_3) = 1, V(Sc_1 \geq Sc_4) = 1$

$V(Sc_2 \geq Sc_1) = 0.7303$ $V(Sc_2 \geq Sc_3) = 1, V(Sc_2 \geq Sc_4) = 1$

$V(Sc_3 \geq Sc_1) = 0.7888$, $V(Sc_3 \geq Sc_2) = 0.9332$, $V(Sc_3 \geq Sc_4) = 1$

$V(Sc_4 \geq Sc_1) = 0.5206$, $V(Sc_4 \geq Sc_2) = 0{,}6397$, $V(Sc_4 \geq Sc_3) = 0.7584$

Then, by using **Sub-step 3**, with the use of **Equation 8**, each weight is calculated.

$d'(C_1) = \min(1, 1, 1.0211) = 1$

$d'(C_2) = \min(0.8812, 1, 1) = 0.7303$

$d'(C_3) = \min(3.6528, 17.8832, 1) = 0.7888$

$d'(C_4) = \min(0.4202, 0.6305, 0.7397) = 0.5206$

Then, the calculated weights vector forms and normalizes the nonfuzzy weight vector below

$W' = (1, 0.7303, 0.7888, 0.5206)$

Then, using **Sub-step 4** and **equation 9**, the weighted priority is normalized to form the following vector regarding the primary goal.

W = (0.328, 0.240, 0.259, 0.171)

Table 31

Priorities Concerning Effective Main Factors Of The Adoption Of Mobile Learning Applications

RANK	Main Factors	Criteria weight
1	**SML**	0.33
3	**WML**	0.24
2	**OML**	0.26
4	**TML**	0.17

Table 31 represents the priorities concerning the main factors affecting mobile learning application adoption.

4.1.2 Sub-factors of mobile learning applications

A). Strengths of mobile learning (SML)

In this study, the Strengths of mobile learning play a crucial role in the adoption of mobile learning application technology. The sub-elements of SML have been investigated and ranked regarding their importance, and their importance is calculated through the FAHP Method.

Table 32

	SML1	SML2	SML3	SML4
SML1	(1.000,1.000,1.000)	(1.000,4.875,11.000)	(1.000,5.540,11.000)	(1.000,5.198,11.000)
SML2	(0.091,0.205,1.000)	(1.000,1.000,1.000)	(1.000,4.383,11.000)	(1.000,4.564,11.000)
SML3	(0.091,0.181,1.000)	(0.091,0.228,1.000)	(1.000,1.000,1.000)	(1.000,4.609,9.000)
SML4	(0.091,0.192,1.000)	(0.091,0.219,1.000)	(0.111,0.217,1.000)	(1.000,1.000,1.000)

The developed fuzzy matrix of the sub-factors of SML

A fuzzy evaluation matrix was developed as a hierarchy structure. Table 32 depicts the evaluation matrix according to the adopted method, FAHP.

Table 33

The sum of rows and columns' sub-factors SML

Sub Factors	Sum of rows	Sum of columns
SML1	(4.000,16.613,34.000)	(1.273,1.578,4.000)
SML2	(3.091,13.448,22.000)	(2,182,6.322,14.000)
SML3	(2.182,6.018,12.000)	(3.111,11.14,24.000)
SML4	(1.293,1.628,4.000)	(4.000,15.371,32.000)
Sum of columns		(10.566,34.411,74.000)

After forming the matrix for comparing pairs of items with fuzzy logic. FAHP determines the weight of each SML criterion. However, according to FAHP methodology, the synthesis extent values should be determined. **Sub-step 1** allows for determining the synthesis extent values according to **Equation 1**. The following calculations show all the extent values.

$$Sc_1 = (4.000, 16.613, 34.000) \otimes (10.566,34.411,74.000)^{-1} = (0.0540, 0.4827, 3.2178)$$

$$Sc_2 = (3.091,13.448,22.000) \otimes (10.566,34.411,74.000)^{-1} = (0.0417, 0.3980, 2.0821)$$

$$Sc_3 = (2.182,6.018,12.000) \otimes (10.566,34.411,74.000)^{-1}$$
$$= (0.0294, 0.1748, 1.1357)$$

$$Sc_4 = (1.293,1.628,4.000) \otimes (10.566,34.411,74.000)^{-1}$$
$$= (0.0174, 0.0473, 0.3785)$$

Table 34

Result of the synthesis values of the sub-factors of SML

Sub Factors	**Sci**
SML1	(0.0540,0.4827,3.2178)
SML2	(0.0417,0.3980,2.0821)
SML3	(0.0294,0.1748,1.1357)
SML4	(0.0174,0.0473,0.3785)

Table 34 represents the synthesis value of the sub-factors of SML.

By using **Sub-step2** the above synthesis value was used to make a comparison using **Equation 6** to obtain the following results:

$V(Sc_1 \geq Sc_2) = 1, V(Sc_1 \geq\ Sc_3) = 1, V(Sc_1 \geq Sc_4) = 1$

$V(Sc_2 \geq Sc_1) = 0.9599\ \ V(Sc_2 \geq\ Sc_3) = 1, V(Sc_2 \geq\ Sc_4) = 1$

$V(Sc_3 \geq Sc_1) = 0.7779\ , V(Sc_3 \geq\ Sc_2 = 0{,}8103\ , V(Sc_3 \geq\ Sc_4) = 1$

$V(Sc_4 \geq Sc_1) = 0.4270\ , V(Sc_4 \geq\ Sc_2) = 0{,}4898\ , V(Sc_4 \geq\ Sc_3) = 0.7324$

Then, with the using **Sub-step3** of **Equation 8**, each weight is calculated:

$d'(C_1) = \min(1, 1, 1) = 1$

$d'(C_2) = \min(0.9599, 1, 1) = 0.9599$

$d'(C_3) = \min(0.7779{,}0{,}8103, 1) = 0.7779$

$d'(C_4) = \min(0.4270\ , 0{,}4898, 0.7324) = 0.4270$

Then, the calculated weights vector forms and normalizes the nonfuzzy weight vector below

$W^{'} = (1, 0.9599, 0.7779, 0.4270)$

Then, using **Sub-step4 Equation 9**, the weighted priority is normalized to form the following vector regarding the primary goal.

W = (0.32, 0.30, 0.25, 0.13)

Table 35

Priorities Concerning Strengths Of Mobile Learning

RANK	Sub Factors	Criteria weight
1	**SML1**	0.32
3	**SML2**	0.30
2	**SML3**	0.25
4	**SML4**	0.13

As shown in Table 35 above, SML1 is the priority according to the SML. According to the obtained weights, the following priorities are assigned to **SML2**, **SML3**, and **SML4**.

B). Weaknesses of mobile learning (WML)

This study investigates the weaknesses of mobile learning applications to admit mobile learning Application technology: The sub-elements of WML that have been investigated and ranked in terms of their importance are calculated using the FAHP Method.

Table 36

The developed fuzzy matrix of the sub-factors of WML

	WML1	**WML2**	**WML3**	**WML4**
WML1	(1.000,1.000,1.000)	(1.000,3.529,9.000)	(1.000,4.751,11.000)	(1.000,3.980,11.000)
WML2	(0.111,0.283,1.000)	(1.000,1.000,1.000)	(1.000,4.187,11.000)	(1.000,4.126,11.000)
WML3	(0.091,0.210,1.000)	(0.091,0.239,1.000)	(1.000,1.000,1.000)	(1.000,4.318,11.000)
WML4	(0.091,0.251,1.000)	(0.091,0.242,1.000)	(0.091,0.232,1.000)	(1.000,1.000,1.000)

A fuzzy evaluation matrix was developed as a hierarchy structure. Table 36 depicts the evaluation matrix according to the adopted method, FAHP.

Table 37

The Sum Of Rows And Columns' Sub-Factors WML

Sub Factors	**Sum of rows**	**Sum of columns**
WML1	(4.000,13.26,32.000)	(1.293,1.744,4.000)
WML2	(3.111,9.596,24.000)	(2,182,5.01,12.000)
WML3	(2.182,5.767,14.000)	(3.091,14.195,24.000)
WML4	(1.273,1.725,4.000)	(4.000,13.424,34.000)
Sum of columns		(10.566,34.373,74.000)

Table 37 represents the sum of rows and columns' Sub-Factors of WML. After forming the matrix for comparing pairs with fuzzy logic, FAHP determines the weight of each criterion of SML. However, according to FAHP methodology, the synthesis extent values should be determined. Using Sub-step1, The synthesis extent values can be determined according to **Equation 1**. The following calculations show all the extent values.

$$Sc_1 = (4.000,13.26,32.000) \otimes (10.566,34.373,74.000)^{-1} = (0.0540, 0.3857, 3.0285)$$

$$Sc_2 = (3.111,9.596,24.000) \otimes (10.566,34.373,74.000)^{-1} = (0.0420, 0.2791, 2.2714)$$

$$Sc_3 = (2.182,5.767,14.000) \otimes (10.566,34.373,74.000)^{-1} = (0.0294, 0.1677, 1.3250)$$

$$Sc_4 = (1.273,1.725,4.000) \otimes (10.566,34.373,74.000)^{-1} = (0.0172, 0.0501, 0.3785)$$

Table 38

Result Of The Synthesis Values Of The Sub-Factors Of WML

Sub Factors	Sci
WML1	(0.0540,0.3857,3.0285)
WML2	(0.0420,0.2791,2.2714)
WML3	(0.0294,0.1677,1.3250)
WML4	(0.0172,0.0501,0.3785)

Table 38 represents the synthesis values of the Sub factors of WML. By using **Sub-step2** the above synthesis value was used to make a comparison using **Equation 6** to obtain the following results:

$V(Sc_1 \geq Sc_2) = 1, V(Sc_1 \geq Sc_3) = 1, V(Sc_1 \geq Sc_4) = 1$

$V(Sc_2 \geq Sc_1) = 0.9541 , V(Sc_2 \geq Sc_3) = 1, V(Sc_2 \geq Sc_4) = 1$

$V(Sc_3 \geq Sc_1) = 0.8535 , V(Sc_3 \geq Sc_2) = 0,9201 , V(Sc_3 \geq Sc_4) = 1$

$V(Sc_4 \geq Sc_1) = 0.4915 , V(Sc_4 \geq Sc_2) = 0,5973 , V(Sc_4 \geq Sc_3) = 0.7484$

Then, using **Sub-step3** and **Equation 8**, each weight is calculated:

$d'(C_1) = \min(1, 1, 1) = 1$

$d'(C_2) = \min(0.9541, 1, 1) = 0.9541$

$d'(C_3) = \min(0.8535, 0.9201, 1) = 0.8535$

$d'(C_4) = \min(0.4915, 0{,}5973, 0.7484) = 0.4915$

Then, the calculated weights vector forms and normalizes the nonfuzzy weight vector below

$W' = (1{,}0.9541{,}0.8535, 0.4915)$

Then, using **Sub-step4** and **Equation 9,** the weighted priority is normalized to form the following vector regarding the primary goal.

W = (0.30, 0.29, 0.26, 0.15)

Table 39

Priorities concerning WML

RANK	Sub Factors	Criteria weight
1	**WML1**	0.30
3	**WML2**	0.29
2	**WML3**	0.26
4	**WML4**	0.15

As shown in Table 39 above, **WML1** is the priority according to the **WML**. According to the obtained weights, the following priorities are assigned to **WML2**, **WML3**, and **WML4**.

C). Opportunities of mobile learning (OML)

This study investigates the opportunities for mobile learning applications to admit the adoption of mobile learning application technology in higher institutions. The sub-factors of OML that have been examined and ranked in importance are calculated using the FAHP Method.

Table 40

	OML1	**OML2**	**OML3**	**OML4**
OML1	(1.000,1.000,1.000)	(1.000,5.214,11.000)	(1.000,4.710,11.000)	(1.000,4.087,11.000)

OML2	(0.091,0.192,1.000)	(1.000,1.000,1.000)	(1.000,5.122,11.000)	(1.000,5.283,11.000)
OML3	(0.091,0.212,1.000)	(1.000,1.000,1.000)	(1.000,1.000,1.000)	(1.000,4.568,11.000)
OML4	(0.091,0.245,1.000)	(0.091,0.189,1.000)	(0.091,0.219,1.000)	(1.000,1.000,1.000)

The Developed Fuzzy Matrix Of The Sub-Factors Of OML

A fuzzy evaluation matrix was developed as a hierarchy structure. Table 40 depicts the evaluation matrix according to the adopted method, FAHP.

Table 41

The Sum of Rows And Columns' Sub-Factors OML

Sub Factors	Sum of rows	Sum of columns
OML1	(4.000,15.309,34.000)	(1.273,1.649,4.000)
OML2	(3.091,11.597,24.000)	(2.182,6.598,14.000)
OML3	(2.182,5.975,14.000)	(3,091,11.051,24.000)
OML4	(1.273,1.653,4.000)	(4.000,14.938,34.000)
Sum of columns		(10.546,34.236,76.000)

Table 41 represents the sum of Rows and Columns' Sub-factors OML. After forming the matrix for comparing pairs with fuzzy logic, FAHP determines the weight of each OML criterion. However, according to FAHP methodology, the synthesis extent values should be determined. Using Sub-step 2, the synthesis extent values can be determined according to **Equation 1**. The following calculations show all the extent values.

$$Sc_1 = (4.000,15.309,34.000) \otimes (10.546,34.236,76.000)^{-1}$$
$$= (0.0526, 0.4471, 3.2239)$$

$$Sc_2 = (3.091,11.597,24.000) \otimes (10.546,34.236,76.000)^{-1}$$
$$= (0.0406, 0.3387, 2.2757)$$

$$Sc_3 = (2.182,5.975,14.000) \otimes (10.546,34.236,76.000)^{-1}$$
$$= (0.0287, 0.1745, 1.3275)$$

$$Sc_4 = (1.273,1.653,4.000) \otimes (10.546,34.236,76.000)^{-1}$$
$$= (0.0167, 0.0482, 0.3792)$$

Table 42

Result Of The Synthesis Values Of The Sub-Factors Of OML

Sub Factors	Sci
OML1	(0.0526,0.4471,3.2239)
OML2	(0.0406,0.3387,2.2757)
OML3	(0.0287,0.1745,1.3275)
OML4	(0.0167,0.0482,0.3792)

Table 42 represents the Synthesis Values of the Sub-Factors of OML. By using **Sub-step2** the above synthesis value was used to make a comparison using **Equation 6** to obtain the following results:

$V(Sc_1 \geq Sc_2) = 1, V(Sc_1 \geq Sc_3) = 1, V(Sc_1 \geq Sc_4) = 1$

$V(Sc_2 \geq Sc_1) = 0.9535, V(Sc_2 \geq Sc_3) = 1, V(Sc_2 \geq Sc_4) = 1$

$V(Sc_3 \geq Sc_1) = 0.8238 , V(Sc_3 \geq Sc_2) = 0.8831 , V(Sc_3 \geq Sc_4) = 1$

$V(Sc_4 \geq Sc_1) = 0.4501 , V(Sc_4 \geq Sc_2) = 0,5382 , V(Sc_4 \geq Sc_3) = 0.7351$

Then, using **Sub-step3** and **Equation 8**, each weight is calculated:

$d'(C_1) = \min(1, 1, 1) = 1$

$d'(C_2) = \min(0.9535, 1, 1) = 0.9535$

$d'(C_3) = \min(0.8238, 0.8831 , 1) = 0.8238$

$d'(C_4) = \min(0.4501, 0,5382, 0.7351) = 0.4501$

Then, the calculated weight vector forms and normalizes the nonfuzzy weight vector below

$W' = (1,0.9535, 0.8238, 0.4501)$

Then, using **Sub-step4** and **Equation 9**, the weighted priority is normalized to form the following vector regarding the primary goal.

W = (0.31, 0.30, 0.26, 0.13)

Table 43

Priorities concerning OML

RANK	Sub Factors	Criteria weight
1	**OML1**	0.31
3	**OML2**	0.30
2	**OML3**	0.26
4	**OML4**	0.13

As shown in Table 43 above, **OML1** is the priority according to the **OML**. According to the obtained weights, the following priorities are assigned to **OML2**, **OML3**, and **OML4**.

D). Threats of mobile learning (TML)

This study investigates the threats to mobile learning applications that would prevent the adoption of mobile learning application technology in higher institutions. The sub-factors of TML that have been examined and ranked in importance are calculated using the FAHP Method.

Table 44

The developed fuzzy matrix of the sub-factors of TML

	TML1	TML2	TML3	TML4
TML1	(1.000,1.000,1.000)	(1.000,3.656,11.000)	(1.000,4.258,11.000)	(1.000,4.432,11.000)
TML2	(0.091,0.274,1.000)	(1.000,1.000,1.000)	(1.000,4.206,11.000)	(1.000,4.445,11.000)
TML3	(0.091,0.235,1.000)	(0.091,0.238,1.000)	(1.000,1.000,1.000)	(1.000,4.428,11.000)
TML4	(0.091,0.226,1.000)	(0.091,0.225,1.000)	(0.091,0.226,1.000)	(1.000,1.000,1.000)

A fuzzy evaluation matrix was developed as a hierarchy structure. Table 44 depicts the evaluation matrix according to the adopted method, FAHP.

Table 45

Sub Factors	Sum of rows	Sum of columns
TML1	(4.000,13.346,34.000)	(1.273,2.735,4.000)
TML2	(3.091,9.925,24.000)	(2.182,5.149,14.000)
TML3	(2.182,6.901,14.000)	(3.091,9.69.24.000)
TML4	(1.273,1.707,4.000)	(4.000,14.305,34.000)
Sum of columns		(10.546,31.879,76.000)

The Sum of Rows And Columns' Sub-Factors TML

Table 45 represents the sum of rows and columns of the Sub-factors TML.

After forming the matrix for comparing pairs with fuzzy logic, FAHP determines the weight of each TML criterion. However, according to FAHP methodology, the synthesis extent values should be determined. Sub-step 1 allows the synthesis extent values to be determined according to **Equation 1**. The following calculations show all the extent values.

$$Sc_1 = (4.000,13.346,34.000) \otimes (10.546,31.879,76.000)^{-1} = (0.0526, 0.4186, 3.2239)$$

$$Sc_2 = (3.091,9.925,24.000) \otimes (10.546,31.879,76.000)^{-1} = (0.0406, 0.3113, 2.2757)$$

$$Sc_3 = (2.182,6.901,14.000) \otimes (10.546,31.879,76.000)^{-1} = (0.0287, 0.2164, 1.3275)$$

$$Sc_4 = (1.273,1.707,4.000) \otimes (10.566,31.054,74.000)^{-1} = (0.0172, 0.0549, 0.3785)$$

Table 46

The Result Of Synthesis Values Of The Sub-Factors Of TML

Sub Factors	Sci
TML1	(0.0526,0.4186,3.2239)
TML2	(0.0406,0.3113,2.2757)
TML3	(0.0287,0.2164,1.3275)
TML4	(0.0172,0.0549,0.3785)

Table 46 represents the result of the synthesis value of the sub-factors of TML. By using **Sub-step2** the above synthesis value was used to make a comparison using **Equation 6** to obtain the following results:

$V(Sc_1 \geq Sc_2) = 1, V(Sc_1 \geq Sc_3) = 1, V(Sc_1 \geq Sc_4) = 1$

$V(Sc_2 \geq Sc_1) = 0.9539\ , V(Sc_2 \geq Sc_3) = 1, V(Sc_2 \geq Sc_4) = 1$

$V(Sc_3 \geq Sc_1) = 0.8631\ , V(Sc_3 \geq Sc_2) = 0.9313, V(Sc_3 \geq Sc_4) = 1$

$V(Sc_4 \geq Sc_1) = 0.4725\ , V(Sc_4 \geq Sc_2) = 0{,}5685\ , V(Sc_4 \geq Sc_3) = 0.6841$

Then, by using **Sub-step3** with the use of **Equation 8**, each weight is calculated:

$d'(C_1) = \min(1, 1, 1) = 1$

$d'(C_2) = \min(0.9539\ , 1, 1) = 0.9539$

$d'(C_3) = \min(0.8631{,}0.9313, 1) = 0.8631$

$d'(C_4) = \min(0.4725{,}0{,}5685, 0.6841) = 0.4725$

Then, the calculated weight vector forms and normalizes the nonfuzzy weight vector below

$W' = (1{,}0.9539{,}0.8631, 0.4725)$

Then, using **Sub-step4** and **Equation 9**, the weighted priority is normalized to form the following vector regarding the primary goal.

W = (0.30, 0.29, 0.26, 0.14)

Table 47

RANK	Sub Factors	Criteria weight
1	**TML1**	0.30
3	**TML2**	0.29
2	**TML3**	0.26
4	**TML4**	0.14

Priorities Concerning TML

As shown in Table 47 above, **TML1** is the priority according to the **TML**. According to the obtained weights, the following priorities are assigned to **TML2**, **TML3**, and **TML4**.

4.1.3 Comparing and evaluation of the main factors:

Based on the findings of this study, which was conducted using the online FAHP questionnaire, this identifies the influential variables in its model and the extent of their contribution to the scale of adoption of mobile learning applications. In terms of normalizing the influential factors in the context of this study, the following rank is provided: It, therefore, becomes the guide for future researchers based on the outcomes of this ranking. The main factors are ranked in the following order, from most important to least important: Strengths of mobile learning (SML) Weighted mean = 0. 33 Opportunities of Mobile Learning (OML) Weighted mean = 0. 26 Weaknesses of mobile learning (WML) Weighted mean = 0. 24 Threats of mobile learning: (TML) weighted mean = 0. 17

In most cases, considering the aforementioned findings and from the viewpoint of the student, the primary factor is Strengths of Mobile Learning (SML)" (w = 0.33) and Opportunities of Mobile Learning (OML)" (w=0.26) with the highest weight, which are the most influential factors for mobile learning application adoption. Then, two criteria were used: "Weaknesses of Mobile Learning (WML)" (w = 0.24) and "Threats of Mobile Learning (TML)" (w = 0.17).

For practical considerations, when students are involved in implementing mobile learning technology in educational settings, they should first consider the primary factors (SML) (OML) and then examine the two factors (WML) (TML) in specific scenarios. When dealing with mathematical operations, scales need to be converted to fuzzy scales. Various types of fuzzy scales can generally be utilized. This study specifically uses the triangular fuzzy transformation scale. (Farhad Lotfi, Kimia Fatehi, Nasrin Badie, 2020) The model has been used.

4.1.4 Comparing and assessment of sub-criteria:

A). Strengths of mobile learning (SML)

In this study, SML is the most critical factor when considering the implementation of mobile learning technology, four sub-factors of SML have been studied and assessed, which are: “Provide flexibility in learning (SM1)", "Engage students in learning (SML2)", "Interactive and helpful in learning (SML3)", and

"Facilitate access across devices and platforms (SML4)".The following four sub-factors are listed in order of importance, from the most important to the least important.: “Provide flexibility in learning (SM1)” (w=0.32), “Engage students in learning (SML2)” (w= 0.30), “Interactive and helpful in learning (SML3) ” (w= 0.25), “Facilitate access across devices and platforms (SML4)” (w= 0.13).

The study suggests that when adopting mobile learning applications, the factor "Provide flexibility in learning (SM1)" should be considered the top priority. "Engage students in Learning (SML2)," Interactive and helpful in Learning (SML3),” and " Facilitate access across devices and platforms (SML4) " Respectively, the flexibility in learning should be investigated and evaluated. The results show that maintaining flexibility is essential for improving student acceptance of mobile learning applications and raising the "SML" level. Nevertheless, this does not mean that other factors are not important enough. Still, this weight (w = 0.32) of the Provide flexibility is far from the different aspects, indicating a high need for this.

B). Weaknesses of mobile learning (WML)

When analyzing the sub-categories of the second primary influential aspect on WML, four sub-categories are under examination. “Lack of support and training (WML1) ”, “Issues related to devices hardware (WML2) ”, “Require stable internet connectivity (WML3) ”, and” Distract students study (WML4)” After the analysis, the sub-factors are ranked from most to least important as follows: “Lack of support and training (WML1)” (w= 0.31), “Issues related to devices hardware (WML2)” (w= 0.29), “Require stable internet connectivity (WML3)” (w= 0.26), ” Distract students study (WML4)” (w= 0.14).

According to the student’s perspective, the mentioned factors, such as the lack of support, are important. training and the issues related to device hardware, are of higher priority. Then, Requiring stable internet connectivity and Distract student's study are important and prioritized, respectively.

C). Opportunities of mobile learning (OML)

Mobile learning opportunities are One of the crucial considerations for implementing mobile learning applications in higher education is the factor of opportunities. In this study, four sub-factors related to opportunities are regarded as the second most significant and influential factor of mobile learning applications, including “Tailor learning experiences (OML1)”, “Facilitate interaction among learners (OML2)", "Integrate new technologies into learning (OML3)", "Promote continuous learning (OML4)".

D). Threats of mobile learning (TML)

Whereas Threats to mobile learning are less It's essential to understand that the outcomes of the sub-criteria can be hotly debated despite their significance in the overall results. Reducing the threats to adoption in higher education is one key factor in adoption that can continuously attract students' satisfaction.

In this questionnaire, four sub-criteria related to TML factors were encompassed. "Security and privacy concerns (TML1)", "Not ensuring equitable access to digital resources (TML2)", and "Barriers to teaching methods and strategies (TML3), Challenges with implementing and using technology for education (TML4). According to the evaluations carried out and extracted by students, the following sub-criteria of TML from the most important to the least one include "Security and privacy concerns (TML1)" (w=0.30), "Not ensuring equitable access to digital resources (TML2)" (w=0.28), Barriers to teaching methods and strategies (TML3)" (w=0.26) "Challenges with implementing and using technology for education (TML4)" (w=0.14).

Among the Threats of mobile learning, Security, and privacy concerns, the priority of these sub-factors lies in their divergence from other sub-criteria. In the second step, three additional sub-criteria are considered. "Not ensuring equitable access to digital resources (TML2)", "Barriers to teaching methods and strategies (TML3)", and "Challenges with implementing and using technology for education (TML4). However, with little difference, they are prioritized.

- Step6: Rank the Criteria

Rank the criteria based on their importance.

Table 48

Assessment of AHP weights and the ranking positions of main and sub-factors.

Main Factors	Weight (W)	Ranking	Sub factors	Weight (W)	Ranking
Strengths of Mobile Learning (SML)	0.33	1	Provide flexibility in learning	0.32	1
			Engage students in learning	0.30	2
			Interactive and helpful in learning	0.25	3
			Facilitate access across devices and platforms	0.13	4
Weaknesses of Mobile Learning (WML)	0.24	3	Lack of support and training	0.30	1
			Issues related to device hardware	0.29	2
			Require stable internet connectivity	0.26	3
			Distract students study	0.14	4
Opportunities of Mobile Learning (OML)	0.26	2	Tailor learning experiences	0.31	1
			Facilitate interaction among learners	0.30	2
			Integrate new technologies into learning.	0.26	3
			Promote continuous learning	0.13	4
Threats of Mobile Learning (TML)	0.17	4	Security and privacy concerns	0.30	1
			Not ensuring equitable access to digital resources	0.28	2
			Barriers to teaching methods and strategies	0.29	3
			Challenges with implementing and using technology for education	0.13	4

Table 48 represents the main factors (Strengths, Weaknesses, Opportunities, and Threats) and gives them weights based on their importance for mobile learning. A list of each main factor's sub-factors, weights, and ranks exists. There are weights for each factor or sub-factor that show how important it is to the total rating of mobile learning. The scores show the value order for each main factor or sub-factor group, such as the main factor in the strengths group, with a weight of 0.32. Regarding the main factors, “Threats of Mobile Learning (TML), The sub-factor “Security and privacy concerns” is ranked as the biggest threat to mobile learning with a weight of 0.30. Overall, this table helps to understand the main and sub-factors that affect ML, their importance, and how they are ranked by how they affect the success and difficulties of mobile learning projects.

Table 49

Weights Concerning Effective Factors Of The Adoption Of Mobile Learning Applications

Rank	Name	Weight
1	SML1	0,315975
2	OML1	0,309846
3	TML1	0,303997
4	SML2	0,303305
5	WML1	0,303112
6	OML2	0,295439
7	TML2	0,289983
8	WML2	0,2892
9	TML3	0,26238
10	WML3	0,258706
11	OML3	0,255251
12	SML3	0,245797
13	WML4	0,14898
14	TML4	0,143638
15	OML4	0,139462
16	SML4	0,134921

Table 49 (continued)

As shown in Table 49 above, according to the Effective factors of adopting mobile learning applications, SML1 is the priority. Next priorities are assigned to OML1, TML1 , SML2 , WML1 , OML2 , TML2 , WML2 , TML3 , WML3 , OML3 , SML3 , WML4 , TML4, OML4, and SML4 according to the obtained weights.

Figure 8

Priorities Concerning Effective Factors Of The Adoption Of Mobile Learning Applications

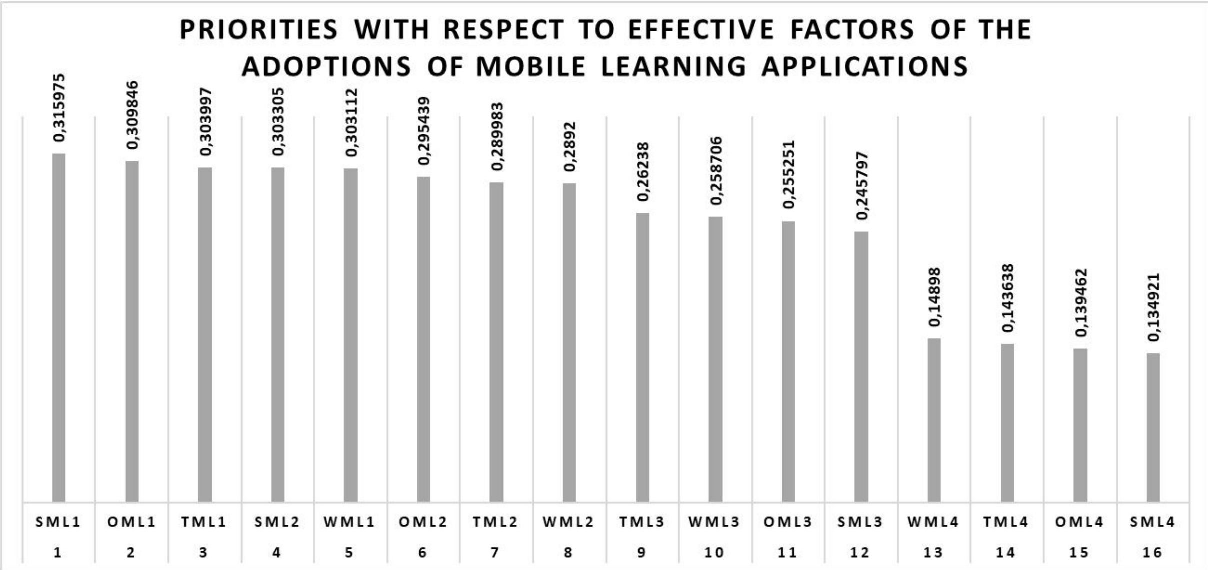


Figure 8 represents the priorities concerning effective factors of adopting mobile learning applications.

4.2 Discussion

Given the momentous changes in information technology worldwide, this research aims to evaluate the factors that affect the adoption of mobile learning applications in higher education.

The results on the strengths of Mobile Learning (SML) in our findings highlight the need for flexibility in learning (SM1) as a first concern for mobile learning acceptance. With a weighted mean of 0.33, SML is highly significant in student adoption of mobile learning technologies. Furthermore, they emphasize that their significant influence in improving mobile learning implementation are elements under SML, including involving students in learning, interaction, and access across devices and platforms. When we compare these results with the SWOT analysis data of other online learning research, we notice certain parallels and contrasts:

Some research stresses the need for adaptability and involving students in their education (Swanson, 2020) . Under the network background, the study's SWOT analysis (Saienko, 2020) concentrates on the advantages of online education, like diversified material and forms, smart playback alternatives, and creative thinking skills. The fuzzy AHP scores in the study (Wang et al., 2022) prioritize these characteristics depending on their importance in improving online learning during the pandemic.

We may make the following contrasts between the weaknesses of Mobile Learning (WML) and other studies concerning the SWOT analysis of online education and E-Learning platforms:

In our findings, lack of support and training (WML1) is akin to the weak practical function (W3) noted in online learning shortcomings (Wang et al., 2022) . Both stress the need for enough support and instruction for good adoption and application. In our findings, problems with device hardware (WML2) can be paralleled with those experienced by students studying English through M-Learning platforms needing excellent training to learn how to control the devices (Parnrod et al., 2020) . Both deal with technical elements that could impede the educational process. Moreover, in our results, we can see that demanding consistent internet connectivity

(WML3) corresponds to the concern of network instability cited in (Adzifome & Agyei, 2023). Both stress the need of consistent connection for flawless education.

Based on findings concerning the potential opportunities of Mobile Learning applications (OML), we can compare them to other studies conducted on the same theme, which gives us a more complete picture. As the primary criterion for the applicability of OML in higher education using mobile learning application technology considered in OML, the possibilities of the element from (Kacetl & Jaroslav, 2019) match: Constructing own thought processes of the student or developing the ability for students to think for themselves or encouraging active learning. Second, it underscores how technology can enhance the process of education. Regarding the opportunities identified by (Mohiuddin et al., 2021), a huge contribution was made towards the acceptance of online learning; the weighted mean for OML equals 0. 26, which suggests the effect of those factors on mobile learning uptake. Both underline the issue of wasting the chances of getting successful educational outcomes.

Furthermore, conjugant to the opportunities found in (Wang et al., 2022) Specifically, the learning and critical thinking opportunities out of the four perceived as significant and influential in adopting mobile learning applications are subfactors that can be aligned with those for autonomous learning. Both researchers recognize some aspects essential in raising the acceptance and efficiency of technological shore learning.

We could also relate the Threats of Mobile Learning (TML) identified in another published research. For example, the assessment unveiled security and privacy concerns (TML1), similar to the insecure network lines cited. (Kacetl & Klímová, 2019) and data theft, as noted in the context of online learning(Wang et al., 2022). Both stress that if we are to ensure that a classroom will always be safe or free from acts of espionage, then concerns about privacy and security must always be addressed. Not promoting the fair utilization of PAI for access to digital resources (TML2) could be compared to the threat of unfair digital access, particularly in rural areas (Kacetl & Klímová, 2019). Both are involved with the questions of openness to achieving the learning material and options. Furthermore, regarding teaching approaches and techniques (TML3), there is no explanation of what a practical function is (Wang et al., 2022). , which is useful to elaborate on the challenges we identified here. Both underscore the challenges that have to be undertaken for the enhancement and achievement of effective teaching and learning practices

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

This chapter discusses an overview of the research studies on adopting mobile learning applications and offers guidelines.

5.1 Conclusion

In conclusion, by applying the fuzzy AHP analysis to rate the factors, the study established the most influential factors that hindered the use of mobile learning applications. The acknowledgment indicates that the study gives an important insight into the key success factors of mobile learning resources regarding acceptance and adoption in higher learning institutes. Furthermore, the findings of this research provide students, instructors, decision-makers, and developers with practical implications that can be utilized to improve the development, implementation, and marketing of mobile learning applications. Through a comprehensive of the prioritized factors that impact adoption, the stakeholder can customize strategies to effectively address particular challenges and take advantage of their strengths to facilitate the easy integration of mobile learning resources.

The study can be considered to enhance what has been written as it offers a framework and a time-honored approach to analyzing how people engage with mobile learning applications. The outcomes generated were proposals regarding ideas as a premise for the subsequent investigations and initiatives to enhance mobile learning in students to promote improved student performance and experience.

5.2 Recommendations

Further studies should, therefore, continue being conducted on mobile learning apps to see how they influence long-term use in different settings. They should also consider how effectively several approaches address such issues as privacy and security, availability of equipment, and pedagogy. Last, they must explore how advanced technologies such as AI and AR can help enhance the learning process. It is also necessary to understand how institutional policies support and professional development further influence the effective deployment of mobile learning technologies in higher learning institutions. This way, understanding stakeholders' sentiments and their desire to incorporate mobile learning apps can be useful in creating user-oriented products.

Adhering to these recommendations will, essentially, gather more information about the factors that lead to the use of mobile learning applications in education systems.

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APPENDICES

Appendix A

NEAR EAST UNIVERSITY

SCIENTIFIC RESEARCH ETHICS COMMITTEE

29.03.2024

Dear Fulbert Milrich Kiminou Nsimba
Your application titled **"Multi-Criteria Decision Approach for Evaluating Factors Affecting Mobile Learning Application Adoption"** with the application number NEU/AS/2024/213 has been evaluated by the Scientific Research Ethics Committee and granted approval. You can start your research on the condition that you will abide by the information provided in your application form.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee

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Appendix B

Survey: Strengths, Weaknesses, Opportunities, and Threats of Mobile Learning Applications

Brief description of the purpose's study:

The study aims to investigate and rank the factors that affect the adoption of mobile learning applications by using multi-criteria decision-making techniques.

Part 1: General Information

Gender:

Male ☐ Female ☐

Age:

Under 18 ☐ 18-20 ☐ 21-23 ☐ 24-25 ☐

Education Level:

Undergraduate ☐

How often do you use mobile learning applications?

Daily ☐ Several times a week ☐ Once a week ☐ Rarely or never ☐

Field of the study

………

Part 2: Evaluation of Criteria

Please rate the following criteria based on their importance for mobile learning applications. Use the Fuzzy AHP scale (1-5) to indicate the relative importance of each criterion compared to the others.

Scale descriptions: 1= Equal, 2= Weakly important, 3= Strongly more important, 4= Very strongly important, 5= Extremely more important.

Q	Main factor	Fuzzy Scale					Main factor
Q1	Strength of mobile learning (SML)	1	2	3	4	5	Weaknesses of mobile learning (WML)
Q2	Strength of mobile learning (SML)	1	2	3	4	5	Opportunities of mobile learning (OML)
Q3	Strength of mobile learning (SML)	1	2	3	4	5	Threats of mobile learning (TML)
Q4	Opportunities of mobile learning (OML)	1	2	3	4	5	Weaknesses of mobile learning (WML)
Q5	Opportunities of mobile learning (OML)	1	2	3	4	5	Threats of mobile learning (TML)
Q6	Threats of mobile learning (TML	2	2	3	4	5	Weaknesses of mobile learning (WML)
Q	Sub-factor	Fuzzy Scale					Sub-factor
Q7	Using the mobile learning application provides flexibility in your learning (SML1)	1	2	3	4	5	I find the mobile learning application engaging for my studies (SML2)
Q8	Using the mobile learning application provides flexibility in your learning (SML1)	1	2	3	4	5	The mobile learning application is interactive and helpful in my learning (SML3)
Q9	Using the mobile learning application provides flexibility in your learning (SML1)	1	2	3	4	5	I can easily access the mobile learning application for my studies (SML4)
Q10	I find the mobile learning application engaging for my studies (SML2)	1	2	3	4	5	The mobile learning application is interactive and helpful in my learning (SML3)
Q11	I find the mobile learning application engaging for my studies (SML2)	1	2	3	4	5	I can easily access the mobile learning application for my studies (SML4)
Q12	The mobile learning application is interactive and helpful in my learning (SML3)	1	2	3	4	5	I can easily access the mobile learning application for my studies (SML4)
Q13	I feel the mobile learning application lacks support and training (WML1)	1	2	3	4	5	I have encountered problems with hardware when using the mobile learning application (WML2)
Q14	I feel the mobile learning application lacks support and training (WML1)	1	2	3	4	5	The mobile learning application requires stable internet connectivity (WML3)
Q15	I feel the mobile learning application lacks support and training (WML1)	1	2	3	4	5	The mobile learning application sometimes distracts me from my studies (WML4)
Q16	I have encountered problems with hardware when using the mobile learning application (WML2)	1	2	3	4	5	The mobile learning application requires stable internet connectivity (WML3)
Q17	I have encountered problems with hardware when using the mobile learning application (WML2)	1	2	3	4	5	The mobile learning application sometimes distracts me from my studies (WML4)

Q18	The mobile learning application requires stable internet connectivity (WML3)	1	2	3	4	5	The mobile learning application sometimes distracts me from my studies (WML4)
Q19	The mobile learning application offers personalized learning experiences. (OML1)	1	2	3	4	5	The mobile learning application facilitates interaction among learners (OML2)
Q20	The mobile learning application offers personalized learning experiences. (OML1)	1	2	3	4	5	The mobile learning application Integrate new technologies into learning (OML3)
Q21	The mobile learning application offers personalized learning experiences. (OML1)	1	2	3	4	5	The mobile learning application supporting lifelong learning (OML4)
Q22	The mobile learning application facilitates interaction among learners (OML2)	1	2	3	4	5	The mobile learning application Integrate new technologies into learning (OML3)
Q23	The mobile learning application facilitates interaction among learners (OML2)	1	2	3	4	5	The mobile learning application supporting lifelong learning (OML4)
Q24	The mobile learning application Integrate new technologies into learning (OML3)	1	2	3	4	5	The mobile learning application supporting lifelong learning (OML4)
Q25	I am concerned about security and privacy when using the mobile learning application. (TML1)	1	2	3	4	5	The mobile learning application does not adequately address differences in access to technology (TML2)
Q26	I am concerned about security and privacy when using the mobile learning application. (TML1)	1	2	3	4	5	I have experienced challenges with the mobile learning application's teaching methods (TML3)
Q27	I am concerned about security and privacy when using the mobile learning application. (TML1)	1	2	3	4	5	The mobile learning application does not handle technical issues well (TML4)
Q28	The mobile learning application does not adequately address differences in access to technology (TML2)	1	2	3	4	5	I have experienced challenges with the mobile learning application's teaching methods (TML3)
Q29	The mobile learning application does not adequately address differences in access to technology (TML2)	1	2	3	4	5	The mobile learning application does not handle technical issues well (TML4)
Q30	I have experienced challenges with the mobile learning application's teaching methods (TML3)	1	2	3	4	5	The mobile learning application does not handle technical issues well (TML4)

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Appendix C

Turnitin Similarity Report

Thesis

ORIGINALITY REPORT

14%	10%	10%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to CSU Northridge Student Paper	2%
2	www.mecs-press.org Internet Source	1%
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4	ojs.bonviewpress.com Internet Source	1%
5	Seren Başaran, Yunusa Haruna. "Integrating FAHP and TOPSIS to evaluate mobile learning applications for mathematics", Procedia Computer Science, 2017 Publication	1%
6	"Mobile Learning in Higher Education in the Asia-Pacific Region", Springer Science and Business Media LLC, 2017 Publication	1%
7	docs.neu.edu.tr Internet Source	<1%