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REVOLUTIONIZING EDUCATION: ASSESSING THE IMPACT OF MOBILE LEARNING APPS ON ACADEMIC SUCCESS AND ATTITUDES

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Abstract: This study examines the impact of mobile learning applications on the academic achievement of gifted students and their attitudes toward mobile learning. A quasi-experimental research design was employed. The study population consisted of all gifted eleventh-grade students in the Al-Ahsa region during the first semester of the 2023-2024 academic year. The study sample included 81 gifted male and female students. The experimental group received instruction based on a mobile learning strategy, while the control group participated in traditional classroom settings. Two instruments were developed to evaluate different aspects. The first tool aimed to examine the impact of mobile learning applications on student achievement and was designed based on the course content, while the second tool was a questionnaire to measure participants' attitudes towards mobile learning. The results revealed statistically significant differences between the average academic achievement of gifted students in the experimental group, who learned using mobile learning, and the average achievement of gifted students in the control group, who learned in the usual way. The difference was in favor of the experimental group. Additionally, there were statistically significant differences between the average level of attitudes toward mobile learning (including dimensions such as satisfaction, impact on learning, motivation, and ease of use) among gifted students in the experimental group and the average level of attitudes toward mobile learning among students in the control group. The difference was also in favor of the experimental group. These findings suggest that the integration of mobile learning applications can have a positive impact on the academic achievement of gifted students and their attitudes towards this learning approach. The study highlights the potential of mobile learning technologies to enhance the educational experiences and outcomes of gifted learners.

Keywords: mobile learning, gifted students, academic achievement, attitudes toward mobile learning, technology-enhanced learning

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INTRODUCTION

The proliferation of mobile technologies has become a ubiquitous phenomenon, with far-reaching implications for the field of education. Recent data from the ICT (Information and Communication Technology) sector reveals the exponential growth in mobile cellular network subscribers, which is expected to reach 5.61 billion by 2024. Simultaneously, the number of Internet users is projected to climb to 5.44 billion during the same period (ICT Facts and Figures, 2024). These staggering statistics underscore the pervasive presence of mobile devices in our daily lives, reshaping the way we interact, communicate, and collaborate (CEPAL, 2022).

Mobile devices, like smartphones and tablets have the potential to revolutionize teaching methods with creative approaches. It's worth noting that while mobile learning can't completely replace education it does offer ways to support learning outside the classroom. This method provides benefits for types of interactions by utilizing the special features of mobile devices to deliver educational content and facilitate learning experiences anytime anywhere.

These devices allow learners to access a range of resources, educational apps and online platforms that enhance their engagement with the subject matter. Additionally mobile technologies provide opportunities for adaptive learning experiences tailored to preferences and styles. A major advantage of learning is its ability to promote collaborative learning through social interactions knowledge sharing and collaborative problem solving via mobile devices. This encourages learning, critical thinking and peer to peer education beyond classroom boundaries.

Furthermore incorporating multimedia elements like videos, images and interactive simulations into content enhances understanding and retention thanks, to integration facilitated by mobile technologies. The convenience and adaptability of gadgets also support engaging learning encounters like augmented reality and virtual reality apps that empower students to discover and engage with simulated settings. Despite its advantages effectively integrating mobile learning necessitates preparation, educational considerations and competent teacher guidance. It's crucial to find a ground, between harnessing the capabilities of technologies and upholding the quality and rigor of educational experiences. Furthermore issues regarding device accessibility and internet connectivity must be resolved to ensure access to mobile learning opportunities, for all students (Oyebola and Ayanlola, 2020; Demir and Akpinar, 2018; Pimmer and Pachler, 2014).

With the increasing utilization of mobile devices in educational settings, the term "mobile learning" has emerged to describe the integration of mobile technologies in learning and teaching activities. The literature presents various definitions of mobile learning, reflecting different perspectives and evolving technologies (Keengwe and Bhargava,

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2014). According to Abduljawad and Ahmad (2023), mobile learning can be understood as a form of e-learning that takes place through mobile devices. This definition emphasizes the use of mobile technologies as a means of delivering educational content and facilitating learning experiences. However, it is important to note that the definition of mobile learning is not static and evolves alongside emerging technologies. In the context of new advancements, Yakar et al. (2015) provide a more comprehensive definition. They describe mobile learning as a form of learning that is instant, optional, and accessible anywhere and anytime. It empowers learners to create their own knowledge, satisfy their curiosity, collaborate with others, and enrich their learning experiences. This definition highlights the key characteristics of mobile learning, including its on-demand nature, flexibility, and ubiquity.

Mobile learning enables learners to access learning materials and engage in educational activities whenever and wherever they choose. This flexibility allows for personalized learning experiences that cater to individual needs and preferences. Moreover, mobile learning promotes learner autonomy and active engagement. Learners have the agency to generate their own knowledge and explore topics of interest, fostering curiosity and self-directed learning. Through mobile devices, learners can collaborate with peers, share ideas, and engage in collaborative problem-solving, enhancing social interaction and knowledge construction. Mobile learning also extends beyond the traditional boundaries of formal education, enabling learners to leverage diverse resources and experiences. By utilizing mobile technologies, learners can access a wide range of information, multimedia content, and online platforms that enrich their learning journey (Criollo et al., 2021).

Mobile learning bridges the gap between individuals in virtual environments and those in the real world, enabling connectivity and interaction (Traxler and Koole, 2014). It facilitates the creation of learning communities among people on the move, fostering collaboration and knowledge sharing. These unique features position mobile learning as a vital element in lifelong learning and in-service training, supporting individuals throughout their educational journeys. The interactive nature of mobile learning extends the reach of education beyond the confines of the traditional classroom, providing sustainability and continuity to the learning process (Demir and Akpinar, 2018). Mobile devices offer opportunities for learning that transcend physical boundaries, allowing individuals to engage in educational activities anytime and anywhere. This flexibility enhances the accessibility and convenience of learning, enabling learners to seamlessly incorporate learning into their daily lives. Furthermore, mobile learning has a significant impact on the socio-cultural and cognitive aspects of learning (Yu et al., 2022). By incorporating mobile devices into the learning process, learners have the opportunity to engage with diverse cultural perspectives, collaborate with peers from different backgrounds, and develop a global understanding of knowledge. Mobile learning also promotes active and personalized learning experiences, as learners can tailor their learning activities to their individual needs and preferences.

Research in the field of mobile learning focuses on understanding how individuals on the move acquire new knowledge, skills, and experiences (Baba et al., 2024; Ally and Prieto-Blzquez, 2014). These studies explore the effectiveness of mobile learning strategies, the impact of mobile technologies on learning outcomes, and the integration of mobile devices into educational practices. However, the rapid development of mobile technologies also presents challenges for researchers and learners alike. Learners need time to familiarize themselves with the unique characteristics and functionalities of new devices, which may initially impact their learning experiences.

Researchers face challenges in conducting longitudinal studies due to the evolving nature of mobile technologies and their impact on learning environments. Additionally, individuals who possess mobile devices often desire to use these devices for their personal needs within mobile learning settings, posing challenges for researchers in controlling variables and maintaining experimental conditions (Baba et al., 2024).

In the realm of mobile learning research, there has been a shift in emphasis from hardware to the design and content aspects of mobile learning (Keengwe and Bhargava, 2014; Göksu and Atici, 2013). While early efforts primarily focused on adapting e-learning objects to mobile devices, contemporary mobile learning research emphasizes the importance of creating mobile learning objects based on mobile design principles. One key principle in mobile learning design involves presenting content in small, easily digestible chunks known as "nuggets" or "bite-sized" learning (Kukulska-Hulme and Traxler, 2019; Burden et al., 2019). Rather than delivering entire course materials, mobile learning content should be broken down into concise units that can be easily consumed on mobile devices. This approach takes into account the limited screen size and attention span of mobile learners, ensuring that the learning materials are optimized for mobile consumption.

Kukulska-Hulme and Traxler (2019) and Burden et al. (2019) outline several design considerations for mobile learning, including:

1. Creating quick and simple interactions: Mobile learning experiences should feature streamlined and intuitive interactions, allowing learners to engage with the content efficiently on mobile devices.
2. Developing flexible materials: Mobile learning materials should be adaptable and responsive to the individual needs and preferences of learners. Flexibility enables learners to customize their learning experiences and access relevant content on the go.
3. Considering device access and interaction: Mobile learning designers should consider the diverse range of mobile devices and standards, ensuring compatibility and seamless user experiences across different platforms.
4. Leveraging the characteristics and constraints of mobile devices: Mobile technologies offer unique features such as GPS, touchscreens, and sensors. Designers should capitalize on these capabilities to enhance the learning experience and create engaging and immersive activities.
5. Treating mobile technologies as learning facilitators: Mobile devices should be seen as more than mere content delivery tools. They should be utilized as active learning facilitators, supporting collaborative learning, knowledge creation, and real-world application of concepts.

6. Adopting a learner-centered approach: Mobile learning materials should be designed with the learner in mind, considering their preferences, learning styles, and goals. Learner-centered design promotes personalized and meaningful learning experiences. By adhering to these design principles, mobile learning can effectively leverage the unique affordances of mobile devices, enhancing learner engagement, accessibility, and the overall learning experience.

In the era of digital technology, mobile devices have become pervasive in society. The rise of Web 2.0 technologies, coupled with the widespread adoption of social network sites, has played a significant role in promoting the acceptance and integration of mobile devices among both teachers and students. This integration of mobile devices in educational settings, both inside and outside the classroom, has yielded positive outcomes, particularly in shaping students' attitudes towards their courses (Chayko, 2014). Mobile learning has proven to be a catalyst for fostering student interest and motivation. By incorporating mobile devices into the learning process, students are presented with dynamic and interactive learning experiences that captivate their attention and fuel their curiosity. The portability and personal nature of mobile devices empower students to engage with educational content at their own pace and convenience, further enhancing their motivation to learn (Keengwe and Bhargava, 2014). Furthermore, the utilization of mobile devices in learning environments serves as an encouragement for active student participation. Mobile learning promotes student-centered approaches, allowing learners to take ownership of their learning journey. The interactive features and collaborative capabilities of mobile devices facilitate communication and knowledge sharing among students, fostering a sense of engagement and community within the learning process. Given these benefits, it can be argued that mobile devices are rapidly becoming a necessity for both students and educators. The seamless integration of mobile devices into educational practices opens up new opportunities for accessing information, collaborating with peers, and engaging in meaningful learning activities. Mobile devices have the potential to enhance the learning experience, promote student satisfaction, and equip students with the skills necessary for success in the digital age (Baba et al., 2024).

Mobile learning offers numerous advantages, including the ability to access learning content beyond traditional course hours. This is made possible through the utilization of mobile learning management systems, which facilitate the delivery of educational materials outside of the classroom setting. Furthermore, mobile learning content is designed with the intention of fostering meaningful and interactive interactions. Researchers have suggested that increasing the duration of access time is beneficial in mobile learning (Criollo et al., 2018).

Additionally, it is important to track and report the duration and number of sessions accessed within the mobile learning system (Demir and Akpinar, 2018). To ensure effective learning experiences through mobile devices, various technical considerations have been proposed. These include the provision of a rapid and wireless internet network infrastructure, ample screen size, and mobile applications available in students' native languages, thereby minimizing extraneous cognitive load (AlAli et al., 2024; Alsidrah, 2022). However, challenges such as distraction, usability difficulties, and technical issues need to be addressed in order to fully exploit the potential of mobile learning.

Mobile learning research has yielded significant implications and recommendations for implementation, demonstrating its positive impact on academic achievement (Demir and Akpinar, 2018; Wishart and Thomas, 2015; Kutluk and Gülmez, 2014). Studies indicate that integrating social networks and mobile technologies enhances student performance and engagement, surpassing traditional instructional methods by providing greater effectiveness and support. The benefits of mobile learning include quick access to information, diverse learning modalities, contextual learning experiences, learner autonomy, increased course participation, and positive effects on academic achievement (Alotaibi and Zeidan, 2023; Mohtar et al., 2023). In line with these findings, this research study has been designed to incorporate bite-sized and interactive course content, utilizing native mobile applications to support learning. Participants personalized their mobile devices and were encouraged to use them throughout the research period. Introducing mobile learning environments to pre-service teachers is a crucial aspect of this research, contributing both empirical and theoretical knowledge to the field.

The primary objective of this research is to explore the effects of mobile learning applications on the academic achievement, attitudes toward mobile learning, and animation development levels of undergraduate students. Specifically, this study aims to address the following research questions:

1. What is the effect of mobile learning on academic achievement?
2. What is the effect of mobile learning on attitudes toward mobile learning?

By addressing these research questions, this study aims to provide insights into the effects of mobile learning applications on academic achievement, attitudes, and animation development levels among undergraduate students. The research design will involve a comparison between an experimental group, which will utilize mobile learning applications, and a control group, which will not have access to such applications. The academic achievement of the two groups will be measured and compared to identify any significant differences. Additionally, the attitudes toward mobile learning and animation development levels of the participants in both groups will be assessed and compared. Furthermore, the study will incorporate qualitative data collection methods to gain an in-depth understanding of students' perspectives on mobile learning in the experimental group. Interviews, surveys, or focus group discussions might be conducted to gather students' views, experiences, and perceptions related to mobile learning. The findings of this research will contribute to the existing literature on mobile learning and its impact on undergraduate students. By examining the effects on academic achievement, attitudes, and animation development levels, this study aims to provide valuable insights for educators, instructional designers, and policymakers in leveraging mobile learning applications effectively in educational settings.

METHODOLOGY

This study employed a quasi-experimental design, explicitly distinguishing between the experimental and control groups. The experimental group (mobile learning group) consisted of 41 gifted students, while the control group (traditional learning group) comprised 40 gifted students. The research study utilized a combination of analytical descriptive and experimental methodologies to effectively address the research objective.

The analytical descriptive approach was chosen for its ability to provide an accurate and organized description of the research problem through the application of scientific methodology. This approach enabled the researchers to obtain and interpret scientific results objectively and impartially, facilitating the achievement of the research objectives. The descriptive component of the study involved a systematic and comprehensive examination of the research problem, using various data collection and analysis techniques. This thorough examination allowed the researchers to develop a detailed understanding of the phenomenon under investigation, thereby laying the groundwork for further exploration. Complementing the analytical descriptive approach, the experimental approach was also employed.

This approach involved an attempt to control the factors that might influence the dependent variables within the experiment (AlAli et al., 2023). By integrating both analytical descriptive and experimental methodologies, the study aimed to provide a robust and comprehensive examination of the effects of mobile learning applications on academic achievement, attitudes toward mobile learning, and animation development levels among undergraduate students.

Participants

To ensure a balanced and unbiased representation, the participants were assigned to the control group and the experimental group using a random sampling technique (AlAli et al., 2023). The use of random sampling helps to minimize selection bias and enhance the generalizability of the research findings.

The study population consisted of all gifted eleventh-grade students in the Al-Ahsa region for the first semester of the 2023-2024 academic year. The study sample comprised a total of 81 gifted male and female students, with 41 students from Al-Anjal National School and 40 students from Alkifah Academy Schools. The participants were identified as gifted by the King Abdulaziz and His Companions Foundation for Giftedness and Creativity "Mawhiba" after passing a series of tests related to gifted students. The male section of Al-Anjal School (20 students) and the female section of Al-Kifah School (21 students) were randomly selected to represent the experimental group.

The female section from Al-Anjal School (20 students) and the male section from Al-Kifah School (20 students) were designated as the control group. It is important to note that participation in the study was entirely voluntary, and the participants were assured of the confidentiality and anonymity of their responses. Ethical considerations were followed throughout the research process, and informed consent was obtained from all participants prior to their involvement in the study. The experimental group used mobile devices (smart phones or tablet computers) in both theoretical and practical courses, while the control group did not have access to these technologies during the study.

Study Design

A quasi-experimental research design was utilized. The study consisted of two groups: the mobile learning group, comprising 41 gifted students, and the traditional learning group, consisting of 40 gifted students. Both groups received equal theoretical and practical courses. The learning materials, including presentations, samples, videos, podcasts, homework, tests, and forums, were made accessible to both groups through a learning management system.

Notably, the mobile learning group received instruction using tablet computers, with the learning management system and learning contents specifically optimized for mobile devices. On the other hand, the traditional learning group experienced instruction in a more conventional classroom setting, with the learning management system and learning contents accessible via the internet. The dependent variables of the research encompassed academic achievement and attitude toward mobile learning, while the independent variables were the mobile learning and traditional learning conditions. Figure 1 provides a visual representation of the detailed research design, illustrating the allocation of participants to their respective groups and the overall experimental setup.

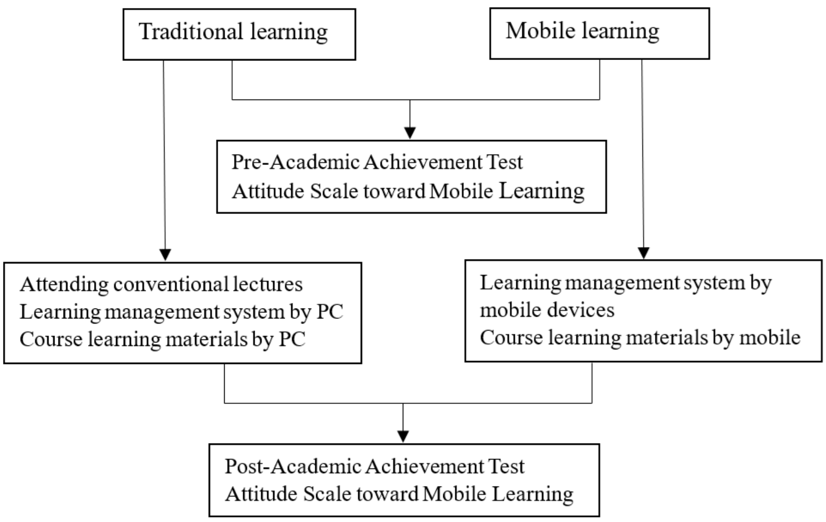

Figure 1. Visual representation of research design, participant allocation, and experimental setup

Study tools

In this study, two instruments were developed to assess different aspects. The first instrument aimed to measure academic achievement and was designed based on the course content. To construct the test, a thorough examination of previous tests in the field was conducted, involving input from domain experts. A total of 30 questions were prepared to assess academic achievement. The second instrument developed for this study was a questionnaire to measure the attitudes of participants toward mobile learning. The Attitude Scale Toward Mobile Learning, previously developed by (Rysbayeva et al., 2022; Demir and Akpınar, 2016, 2018; Yorganci, 2017), served as the foundation for this questionnaire. Initially, the questionnaire included four main dimensions, the first is Satisfaction and includes (12) items, the second is Effect to learning and includes (12) items, the third is Motivation and includes (13) items, and the fourth is Usability and includes (13) items.

An initial copy of the questionnaire consisting of 50 items was developed. To rate their attitudes, participants were asked to use a 5-point Likert scale, with the following response options: Strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1). This scale provided a range of choices for participants to indicate their level of agreement or disagreement with each item in the questionnaire, allowing for a nuanced assessment of attitudes toward mobile learning.

The validation of the reliability and validity of the tools

The developed tools underwent a rigorous review process to ensure their validity and appropriateness. A panel of expert arbitrators, composed of professors specializing in mathematics, measurement, evaluation, and mathematics education from various Saudi universities, played a critical role in examining the tools. Their expertise and insights were invaluable in refining the instruments. Based on the opinions of the expert panel, the researchers made necessary modifications to improve the tools. Ambiguous and unclear words and items were clarified, grammatical errors were corrected, and items that were deemed inappropriate or duplicated by at least 30% of the experts were removed. In total, 6 questions were deleted from the first scale, which is the test, and 8 items were deleted from the second scale, which is attitudes toward mobile learning. The feedback and suggestions provided by the panel of arbitrators were meticulously analyzed by the researchers. Incorporating these expert recommendations, the tools underwent necessary adjustments to enhance their refinement and appropriateness. This thorough scrutiny and iterative refinement process, involving both the researchers and the esteemed panel of arbitrators, ensured that the tools used in the study were methodically developed and met the required standards of validity and appropriateness. The careful consideration of expert feedback and the iterative nature of the refinement process contributed to the tools' overall quality and reliability. The final copy consisted of 42 items, where the first dimensions is the Satisfaction and includes (10) items, the second is the Effect to learning and includes (10) items, the third is Motivation and includes (11) items, and the fourth is the Usability and includes (11) items.

To establish the validity and reliability of the developed tools, a pilot study involving 25 respondents was conducted. The researchers employed various indicators and statistical techniques to assess the construct validity of the measurement tools. To evaluate the construct validity, indicators such as Macdonald's Omega and Composite Reliability were examined. These indicators provide insights into the internal consistency and reliability of the measurement instrument. Additionally, the study assessed convergent and discriminant validity, which examine the extent to which the instrument accurately measures the intended constructs and differentiates them from other constructs (Saleh and AlAli, 2024; AlAli and Saleh, 2022).

Confirmatory factor analysis (CFA), a statistical technique under the umbrella of structural equation modeling (SEM), was utilized to establish factor validity. The researchers employed statistical software like SPSS and Amos to conduct the CFA. This analysis helps uncover underlying patterns within the data by exploring the relationships between latent constructs. CFA is a valuable tool at various stages of research, including the development of measurement tools, evaluation of construct validity, and analysis of methodological influences. CFA serves as a cornerstone during the instrument's development process. It verifies the latent structure of the measurement tool and confirms the main dimensions and factor loadings inherent in the instrument. As such, CFA is an indispensable analytical technique that significantly contributes to the psychometric assessment of the tools (AlAli and Al-Barakat, 2022).

Indicators and coefficients of construct validity

This section presents the indicators and coefficients used to assess the construct validity of the measurement instrument. To evaluate the reliability of the scales, commonly used indicators such as Macdonald's Omega and composite reliability (CR) were calculated. As shown in Table 1, the values of McDonald's Omega and CR for the first scale (the test) is 0.897, while for the second scale, the value is 0.956. These values exceed the recommended threshold of 0.7, indicating a high level of internal consistency for the scales. Furthermore, the average variance extracted (AVE) values were examined to assess the convergent validity of the measurement instrument. The AVE values were 0.673 for the first scale and 0.795 for the second scale, both of which exceed the threshold of 50%. This suggests that a significant proportion of the variance in the items is accounted for by the latent constructs, providing evidence of convergent validity.

Table 1. Indicators and coefficients used to assess construct validity

Tool		Items	Loading Factor	Macdonalds Omega	CR	AVE	$\sqrt{AVE}$
Academic achievement test		24	0.45-0.67	.822	.831	0.641	0.800
Attitudes of participants toward mobile learning		42	0.58-0.68	.808	.812	0.716	0.846

In addition to reliability and convergent validity, the researchers also evaluated the discriminant validity of the scales. This was done by comparing the square root of the AVE values with the internal correlations between the latent variables or factors. The results indicated that the square root of the AVE values exceeded the internal correlations, meeting the criteria for discriminant validity (AlAli and Saleh, 2022; AlAli, 2020). To verify the validity of the factorial structure of the measurement scales, the researchers applied the final versions of both scales to the study sample. This was followed by the conduct of confirmatory factor analysis (CFA) on each scale to evaluate the relationships between the items and their respective scales. The CFA analyses provided insights into the factor loading values of the items on their corresponding scales. As per the recommended guidelines, the factor loading values must not be less than 0.40 for the items to be considered for inclusion in the scales (AlAli and Al-Barakat, 2022).

The adopted models illustrating the relationships between the items and their respective scales are presented in Figure 2 and Figure 3. These visual representations provide a clear depiction of the factor structures and the associated loading values for each item. By examining the factor loading values, the researchers were able to confirm that all items included in the final versions of the scales met the minimum threshold of 0.40. This indicates that the items are strongly aligned with their intended latent constructs, demonstrating a robust factorial structure for the measurement instruments. Figure 2 and Figure 3 display the factor loadings for each item. According to AlAli and Al-Barakat (2022) and AlAli (2024), a minimum loading value of 0.40 was required for inclusion. The analysis revealed that all items met this criterion, with factor loadings exceeding 0.40 on their respective scales.

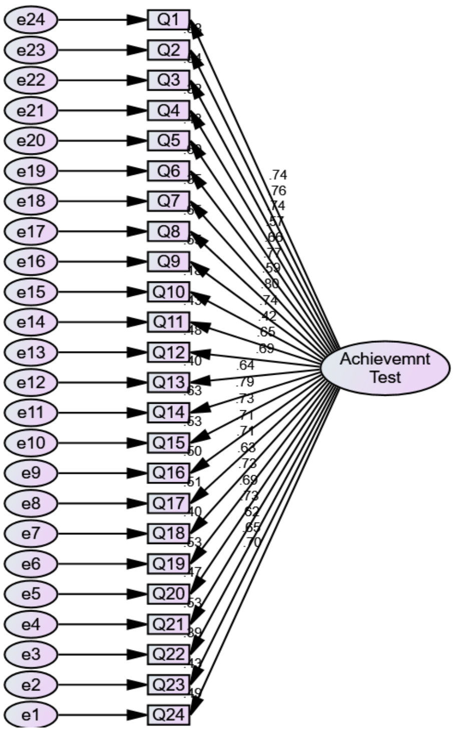

Figure 2. Confirmatory factor analysis results for the academic achievement test scale items model

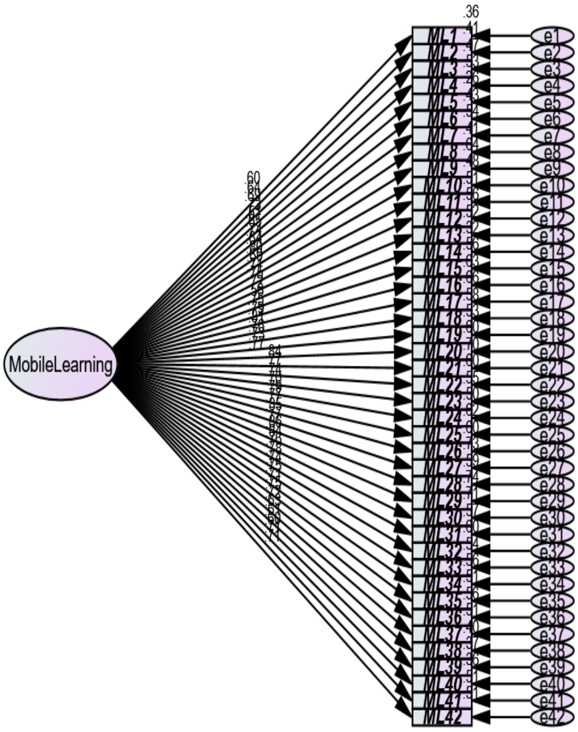

Figure 3. Confirmatory factor analysis results for the attitudes toward mobile learning scale items model

Findings

To answer of the first question: What is the effect of the mobile learning on academic achievement? Means and standard deviation were calculated. In addition, the t-test was used. Table 2 below shows the means, standard deviation, and results of the t-test for two groups to examine the significance of differences in the academic achievement test according to the mobile learning. The data in Table 2 indicates a difference between the average scores of students in the experimental and control groups. For the pre-achievement test, the experimental group had a mean score of 4.52 with a standard deviation of 3.19, while the control group had a mean of 4.66 and a standard deviation of 3.23. On the post-achievement test, the experimental group's mean score was 18.56 with a standard deviation of 2.05, and the control group had a mean of 13.39 and a standard deviation of 5.46. Table 2 also shows that there were statistically significant differences between the average achievement of students on the academic achievement test who learned using the mobile learning (Experimental group) and the average achievement of students on the academic achievement test who learned in the usual way (Control group), and the difference came in favor of the experimental group. To find out the effect of the mobile learning on academic achievement, the Eta Square (η2) was used. Table 3 shows the values for the effect size levels.

Table 2. The means, standard deviation, results of the t-test for two groups (* Statistically significant at level 0.05)

Test	Group	N	Mean	Std. Deviation	T-Value	Sig.
pre- academic achievement test	Experimental	41	4.52	3.19	5.02	0.09
	Control	40	4.66	3.23		
post- academic achievement test	Experimental	41	18.56	2.05	7.09	0.00*
	Control	40	13.39	5.46		

Table 3. The values for the effect size levels (Source: Cohen, 1988)

Effect Size	Small	Medium	Large	Range
η2	0.01-0.06	0.06-0.14	≥ 0.14	[0-1]

To find out the effect of the mobile learning on the achievement of students on the academic achievement test, the Eta Square (η2) was used. The value of η2 was 0.413, which is a large value. This means that the use of the mobile learning explains 41.3% of the students' performance. To answer of the second question: What is the effect of the mobile learning on attitudes toward mobile learning? Means and standard deviation were calculated. In addition, the t-test was used. Table 4 below shows the means, standard deviation, and results of the t-test for two groups to examine the significance of differences in the scale of attitudes toward mobile learning according to the mobile learning.

Table 4. The means, standard deviation, results of the t-test for two groups (*Statistically significant at level 0.05)

variable	Group	N	Mean	Std. Deviation	T-Value	Sig.	Statistical significance
Satisfaction	Control	40	3.89	2.19	3.12	0.00	Statistically significant
	Experimental	41	4.25	2.76			
Effect to learning	Control	40	3.76	1.51	3.61	0.02	Statistically significant
	Experimental	41	4.67	1.42			
Motivation	Control	40	3.85	1.23	2.93	0.01	Statistically significant
	Experimental	41	4.42	1.67			
Usability	Control	40	3.88	2.07	3.51	0.01	Statistically significant
	Experimental	41	4.91	2.42			
Overall Degree	Control	40	3.85	3.47	5.01	0.01	Statistically significant
	Experimental	41	5.23	3.89			

Table 4 showed that the mean value in the application of the control sample was less than the mean value in the application of the experimental sample of the attitudes toward mobile learning. Where the mean value response of control group to attitudes toward mobile learning (3.85) was lower than the mean value response of experimental group (5.23). This shows that there were statistically significant differences between the average level of attitudes toward mobile learning among students who learned using the mobile learning (Experimental group) and the average level of attitudes toward mobile learning among students who learned in the usual way (Control group), and the difference came in favor of the experimental group.To find out the effect of the mobile learning on the attitudes toward mobile learning of students, the Eta Square (η2) was used. The value of η2 was 0.392, which is a large value. This means that the use of the mobile learning explains 39.2% of the students' attitudes.

DISCUSSION

The results presented in the data indicate that there were statistically significant differences between the average achievement of gifted students on the academic achievement test in the experimental group, who learned using mobile learning, and the control group, who learned in the traditional way. The difference in the mean scores favored the experimental group. These findings align with the results of previous studies (Demir and Akpinar, 2018; Wishart and Thomas, 2015; Kutluk and Gülmez, 2014; Chu, 2014; Ozan, 2013; Oberer and Erkollar, 2013; Hwang and Chang, 2011) that have examined the impact of mobile learning on gifted student academic achievement. Several studies have consistently demonstrated that the use of mobile learning technologies can lead to enhanced learning outcomes compared to traditional instructional methods.

The potential reasons for the superior performance of the experimental group in this study may be attributed to the unique features and affordances of mobile learning, such as increased student engagement, personalized learning opportunities, and the ability to access educational resources anytime and anywhere. The mobile learning approach may have provided students with more interactive, dynamic, and tailored learning experiences, ultimately leading to better academic achievement. Mobile learning platforms often incorporate interactive features, gamification elements, and real-time feedback, which can enhance student engagement and motivation.

The experimental group may have experienced increased interest, curiosity, and a sense of ownership over their learning, leading to better academic performance. Mobile devices allow for personalized learning experiences, where content and activities can be tailored to individual students' needs, abilities, and learning preferences. This personalization can better cater to the unique learning styles and paces of gifted mathematics students, optimizing their learning outcomes. Mobile learning provides students with anytime, anywhere access to educational resources, such as digital textbooks, video lessons, and interactive simulations. This flexibility and access to a wealth of information may have empowered the experimental group to explore topics in-depth, reinforcing their understanding and application of mathematical concepts. Mobile devices can facilitate collaborative learning, enabling students to engage in group discussions, peer-to-peer tutoring, and shared problem-solving activities. The experimental group may have benefited from the social interactions and collective knowledge-building, further enhancing their academic performance.

Mobile learning platforms often incorporate features for real-time feedback, formative assessments, and progress tracking. This immediate feedback may have helped the experimental group identify their strengths, weaknesses, and areas for improvement, leading to more targeted learning and better academic results.

The data presented also reveals statistically significant differences between the average level of attitudes toward mobile learning among students in the experimental group, who learned using the mobile learning approach, and the control group, who learned in the traditional way. Importantly, the difference in attitudes was in favor of the experimental group. These findings are consistent with the results of previous studies that have examined the impact of mobile learning on students' attitudes and perceptions (Pham and Truong, 2023; Rysbayeva et al., 2022; Korucu and Bicer, 2018; Al-Emran et al., 2016). The existing body of research has consistently demonstrated that the integration of mobile technologies into the learning process can lead to more positive attitudes and increased acceptance of mobile learning among students. For instance, some studies (Anuyahong and Pucharoen, 2023; Liu and Correia, 2021; Demir and Akpinar, 2018; Gikas and Grant, 2013) found that students who engaged in mobile learning activities exhibited greater satisfaction, perceived the mobile learning platform as more useful and easy to use, and were more motivated to learn compared to their peers in the control group who received traditional instruction. Similarly, some studies (Liu et al., 2018; Demir and Akpinar, 2018; Kutluk and Gülmez, 2014; Martin and Ertzberger, 2013) reported that the experimental group that learned through a mobile-based collaborative learning approach showed significantly higher levels of motivation and perceived usefulness of the mobile learning environment than the control group.

Several factors may have contributed to the more favorable attitudes toward mobile learning observed in the experimental group. The interactive, personalized, and dynamic nature of the mobile learning environment may have fostered a greater sense of engagement and enjoyment among the students in the experimental group. The engaging features and interactive content of the mobile learning platform could have enhanced the students' learning experience, leading to more positive attitudes. The experimental group may have recognized the potential benefits and effectiveness of mobile learning in improving their academic performance, as evidenced by their superior achievement results. This perceived usefulness and effectiveness of the mobile learning approach could have positively influenced the students' attitudes.

Mobile learning often provides students with greater autonomy and control over their learning, allowing them to pace themselves, access resources, and explore topics at their own discretion. This sense of autonomy and control may have contributed to the experimental group's more favorable attitudes toward mobile learning. The ubiquitous access to educational resources and the flexibility offered by mobile devices may have been particularly appealing to the experimental group, leading to more positive attitudes. The convenience and ease of use of the mobile learning platform could have enhanced the students' overall learning experience. For some students, the introduction of mobile learning may have been a novel and innovative approach, which could have piqued their interest and curiosity, resulting in more positive attitudes.

Recommendations

Based on the findings of the current study and the consistency with previous related research, educational institutions should consider integrating mobile learning strategies and incorporating the use of mobile devices (e.g., smartphones, tablets) into the learning experiences of gifted students. Providing comprehensive training and professional development opportunities for educators on the effective integration of mobile learning technologies, and encouraging the development of mobile-friendly educational content and resources tailored to the needs and interests of gifted students, can help leverage the benefits of personalization, interactivity, and enhanced engagement to support the unique learning styles and cognitive abilities of this population. Furthermore, conducting expanded research to explore the long-term effects of mobile learning on the academic achievement, motivation, and overall learning experiences of gifted students, while also involving parents and other key stakeholders in the implementation process, can help ensure the successful and impactful integration of mobile technologies in the education of gifted learners across diverse educational settings.

Future directions

For future directions in the research and application of mobile learning for gifted students, educational researchers and practitioners should consider conducting long-term, longitudinal studies to examine the sustained impact of mobile learning on the academic achievement, skill development, and overall learning outcomes of gifted students over an extended period, while also exploring the integration of adaptive and personalized learning algorithms within mobile learning platforms to provide tailored educational experiences that cater to the individual strengths, learning preferences, and pacing needs of this population.

Additionally, examining the potential of combining mobile learning with other instructional modalities, such as virtual reality, augmented reality, or game-based learning, to create immersive and multisensory learning environments for gifted students, as well as investigating the accessibility and inclusivity of mobile learning platforms for gifted students with diverse needs, can further enhance the impact of these technologies.

Expanding the research on effective teacher professional development programs that equip educators with the necessary skills and knowledge to leverage mobile technologies in their instruction of gifted students, and investigating ways to enhance parental engagement and home-school collaboration in the context of mobile learning for gifted children, can also contribute to the continued advancement and optimization of mobile learning initiatives for this unique and intellectually talented group of learners.

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