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Methods of implementing mobile learning applications in the training of future computer science teachers

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ABSTRACT

One of the challenges of integrating mobile applications in computer science teachers' training is ineffective pedagogical design, poor implementation and technical infrastructure which requires urgent investigation. Consequently, the study explores the methods of implementing mobile learning applications to train future computer science teachers. Three research questions guided the study. The study adopted a pretest-posttest research design consisting of the experimental and control groups. The study respondents were 100 students from L.N. Gumilyov Eurasian National University. Pretest and posttest instruments, observation protocols and surveys were used in the study. Descriptive and inferential statistics were used for data analysis. The study's findings revealed a significant difference in students' academic performance in the experimental group compared to those in the control group. The study's findings also revealed that learners' attitudes towards using mobile applications in learning are positive. It was recommended among others that Educators should carefully select and implement mobile applications that align with the students' learning objectives to enhance student learning. Suggestions were also made for further studies.

Keywords: Mobile learning applications, Computer science teachers, Professional training

1. Introduction

Globally, education serves as a vital foundation through which individuals learn societal values, acquire knowledge and skills, and develop their potential to become active and contributing members of society. Education refers to any activity that cultivates the innate potentials of people, which aid them to make good decisions and address personal and societal problems; this in turn promotes the development of man and the world at large [1]. It inculcates in people suitable knowledge and builds their capacity and skills required to survive in 21st century.

The implication is that education shapes people's critical thinking, fosters economic growth, and empowers lifelong success, more particularly now that digital technologies have become important to keep up with modern technologies [2]. The way technology transforms academic activities, create flexible setting for learners, boosts students involvement and also allows customized experiences makes the shift to digital learning a necessity. In the words [3], digital transformation simply refers to the integration of all kinds of digital tools into teaching-learning process to enhance academic activities and performance of learners.

In education, [4] maintain that digital transformation is the use of digital tools and resources to support academic activities to create flexible and interactive educational experience. One can infer that digital transformation is a shift towards the use of modern technologies to promote academic environment. It is important to integrate digital tools in education as a way to prepare people's mind towards attainment of meaningful success in the 21st century where the use of digital technologies are inevitable [5]. Hence, adopting effective strategy to allow changes based on expert assessment and system approach is vital and the major way to achieve this, is through digital transformation [6].

The advent of mobile technologies has made digital transformation more popular in education, as it servers as platform through which students interact with teachers, peers, participate effectively in academic activities and also access different learning resources conveniently [7].

Therefore, mobile learning is a key component of digital transformation, providing students with diverse opportunities for collaborative, self-directed, and personalized learning experiences. Mobile learning involves using mobile devices to enhance teaching and learning, help learners participate effectively in online discussions, and experience learning activities. This is why [8] posits that the emergence of mobile technologies in learning is realistic because mobile devices are compelling and used everywhere. This allows students to study at their convenience.

Mobile learning helps educators to provide timely interventions for students, track students' academic success and also helps them to encourage good feedback and assessment practices. As a result, different kinds of innovative learning applications, tools and platforms cater to students' needs and preferences in the teaching-learning process [9]. Mobile learning applications are primarily designed to enhance mathematics skills, language learning or professional development. They also harness experiential learning to capture students' experiences [10]. This is achieved through the use of audio recordings, videos and videos.

However, there is a limited number of studies examining the impact of teacher training, especially in computer science education. While numerous studies have explored the use of mobile technologies in learning and the growing demands in the field of computer science, there remains a lack of experimental evidence assessing how mobile applications can be effectively utilized in the professional training of future computer science teachers, including identifying the most effective implementation methods.

The point being stressed is that different scholars have conducted researches on the importance of mobile learning, in the area of flexibility and accessibility. Nonetheless, to best of researchers' knowledge, there is paucity of studies regarding how mobile application fosters effective learning, let alone, enhancing trainee teachers, especially in computer science education. In addition, other studies conducted so far lack empirical evidence and this has become a matter of concern to many scholars because of the technological advancements in present time. There is also limited work that fully investigates and resolves the teaching approaches and practical tools needed to improve learning, especially in computer science education. In this regard, carrying out an experimental study can go a long way to addressing issues by providing educators with teaching and learning experiences that are more flexible, interactive and accessible.

Another concern is that, without experimental evidence, identifying the most effective ways to design and evaluate mobile applications for teacher training (particularly in computer science education) remains difficult. As a result, researchers continue to question which functionalities and teaching-learning approaches can maximize the benefits of mobile technologies on the overall academic performance of trainee computer science teachers. Therefore, conducting an experimental study is essential to determine the impact of mobile applications on the academic success of future science educators.

Interestingly, the researcher has not encountered experimental studies that explore how learners perceive the effectiveness of digital technologies in enhancing learning. Most of the existing research varies widely in methodology and content scope. Additionally, studies employing experimental designs to identify the most effective ways to integrate mobile applications for improving digital competence and, more broadly, learner engagement are scarce.

Be that as it may, future educators are expected to be tech-savvy and adaptive teachers equipped with the required competencies and skills to implement emerging technologies effectively into teaching-learning processes. When future educators are tech-savvy and adaptive professionals, they can enhance students' learning, academic engagement and overall achievement. Tech-savvy educators can utilize online platforms and digital tools to make learning more interesting with a more personalized learning experience for students.

This addresses the challenges learners encounter in the 21st century by equipping them with the potential for responding to new technologies, curriculum requirements and pedagogies. By so doing, students will be motivated to acquire the competencies, skills and knowledge necessary to succeed in a computer science education, particularly in the 21st century.

Tech-savvy and adaptive teachers have never been taken seriously, and due to digital transformation in education, it is vital to prepare future educators adequately to meet and address the challenges and opportunities of the present time. Based on the foregoing, examining methods of implementing mobile learning applications among computer science educators under training becomes necessary.

This study aims to examine the effectiveness of integrating mobile learning applications into the professional training of future computer science teachers and identify optimal methods for their implementation.

Three questions were posed for the study:

1. What impact do mobile learning applications have on the academic performance of future computer science teachers?

2. How do students perceive using mobile applications in their learning process?

3. What mobile application integration methods are most effective in enhancing digital competence and engagement?

1.1. Mobile learning's theoretical foundations

Mobile learning is rooted in several key concepts and theories. This key concept and theory appear to underpin the development, design and implementation of mobile learning experiences. According to [11], situated cognition is indeed part of the theoretical foundations of learning using mobile technologies. This theoretical foundation is learning that occurs in the context in which it is situated. Therefore, mobile learning is utilized by educators to enhance this concept. To do that effectively requires learners to access different learning resources and be allowed to engage in academic activities daily. The second key theoretical foundation is social constructivism.

As [12] rightly puts: mobile learning is a vehicle for promoting learning effectiveness among learners since learning takes place through international collaboration. This process is enhanced through mobile learning as it fosters interaction between teachers, learners, peers through mobile technologies. This enhances collaborative learning and also make education more engaging, flexible and interactive.

Experiential learning theory is another major framework that supports mobile learning, as it hinges on learning by doing and direct experience. Simply interpreted, learners conduct hands-on research, participate in educational games which mostly reflect on they captured using mobile technologies. In addition, informal learning is one of the aspects of mobile learning theory. It stipulates that learning does not only occur in the classroom buildings [13].

Thus, mobile learning is a platform through which learners participate in academic activities irrespective of their location. Through digital technologies, learners get personalized learning tools, track their success and set their goals. By way of recapitulation, the theoretical foundations of mobile learning are rooted in key concepts and theories [14].

These key concepts and theories encourage experience, social interaction, personalization and informality in the teaching-learning process [15]. Through these theoretical foundations, mobile learning caters to learners' individual needs and preferences by making their learning experiences more engaging, accessible and flexible.

1.2. Mobile application use in higher education and teacher training

Research has been conducted on mobile apps in higher education and teacher training. To some extent, these studies showed positive results regarding adopting and effectively using emerging technologies in promoting student engagement and experiences. The findings by [16] revealed that mobile apps help facilitate personalized and flexible learning.

When learning becomes flexible and personalized, students get different kinds of learning tools, and such students will participate in their academic activities at their own pace and convenience. Similarly, [17] deduced that mobile apps encourage community and social learning, collaborative learning and peer-to-peer interaction. Relating this to teacher training, one can infer that mobile apps provide educators with interactive and accessible resources to encourage professional development.

In addition, [18] supported that it is through mobile apps that teachers access just-in-time learning resources. Mobile apps also allow teachers to respond with maximum flexibility to the needs of their students. In another view, [19] reported that mobile apps enhance community and collective responsibility among teachers and allow teachers to share their knowledge with students.

Furthermore, research has also shown the effects of using mobile apps to enhance teacher training in some compulsory subjects, particularly science and mathematics. In this vein, [20] posits that teachers have access to learning resources that are engaging and interactive through mobile apps. This helps them to promote teaching effectiveness, enhance students' understanding and academic achievement.

More so, [21] stresses that teachers design and implement inquiry-based science lessons, encourage scientific literacy and promote students' academic engagement. Based on the foregoing, mobile apps can promote learners' academic activities and learning experiences in higher education and teacher training. However, it is still essential to carry out an experimental study to fully identify the measures for effective implementation of the mobile learning applications among computer science educators under training in tertiary institutions.

1.3. Specific focus on computer science education

Many researchers have defined computer science education. To buttress this fact, [22] defines computer science education as simply the process of teaching and learning the concepts, theories, principles and computer science practices such as data structures, programming, software engineering and algorithms.

Similarly, [23] posits that computer science education is a branch that covers both the technical computing [24], ethical, social and cultural effects of digital technologies, to produce graduates who can design, apply and develop computational systems to solve real-world problems. However, computer science education is now regarded as an essential discipline in the 21st century because of the advent of modern technologies in higher education and teacher training.

According to [25], computer science education deals with applying computational thinking, computational systems, programming languages and algorithms, which is geared towards solving different kinds of problems in real time. Computer science education is therefore a branch of science education that provides learners the basic competencies and skills needed to be creative, solve problems critically, and develop, design and apply computational systems to address the challenges of the 21st century.

Computer science education teaches learners how to address human problems using computational systems. This may explain why Ref. [24] argues that computer science education teaches learners to tackle real-world challenges with computational abilities such as data structures, software design, and programming languages. It shows that computer science concepts are applied across sectors- healthcare, education, finance, entertainment- and are central to developing computational thinking.

Computational skills are valuable because they are beneficial in all spheres of life. According to [26], computational thinking means breaking down challenges that are complicated in a way and manner that is manageable, developing algorithms and analyzing data to solve real-life problems in the 21st century.

Computer science education equips students with computational thinking, enabling them to reason logically, think critically, and develop problem-solving skills. Given the demand for computer science professionals in society, many graduates are motivated to pursue careers in fields such as artificial intelligence, cybersecurity, software development, and other related areas.

Different studies [27] agree that computer science educates students on technology's cultural and social effects. By so doing, computer science education helps students acquire more knowledge on promoting industrial inclusion and diversity.

1.4. Types of applications used in prior studies

So many researchers have examined the applications used in educating teachers about computer science. According to [21], mobile applications used in computer science can be grouped into different categories, including multimedia tools, coding platforms, game-based learning environments and simulations. Some examples of coding platforms include GitHub and Scratch.

These coding platforms appear to have been used in many studies to support programming education. In the view of [28], it is through these platforms that coding resources and tools are provided to students. Some of these coding tools and resources include tutorials, projects, and an interactive coding environment, which help students develop programming skills and help them work on real-world projects. Furthermore, many studies have also used simulations to enhance the study of computer science among teachers. According to [29], interactive and immersive learning experiences are provided to students through simulations. These learning experiences provided to students help them to examine concepts and systems in a more controlled environment. For instance, simulations are often used to support traffic flow or population dynamics. Through this, students experiment and learn using the trial-and-error method.

Another application that supports learning and teaching computer science is a learning environment based on games. Many researchers have used the baseline learning environment to enhance learning in computer science education. In this regard, the game design elements and mechanics enhance learning and promote students' academic engagement. A good example of this assertion is using games to teach programming concepts or introducing students to computational thinking. Multimedia tools, more particularly interactive animations and video tutorials, have been used by many studies to enhance the teaching-learning process in computer science education [30]. These multimedia tools tend to provide learners with interactive concepts that are visualized.

1.5. Challenges and best practices reported in literature

Some studies reviewed so far have shown many problems and best practices that are very important for digitalizing computer science education using modern technologies. In this regard, [30] opines that disadvantaged learners do not readily access mobile technologies, let alone internet connectivity.

Teachers find it challenging to develop and design a very sound pedagogical mobile learning experience, which is essential and highly engaging to students in computer science education [31]. In addition, educators seem to find it challenging to develop new competencies and skills needed to implement mobile technologies into teaching-learning practices in computer science education. To achieve this, there is a need to support teachers and utilize professional development programs to promote student learning activities regarding mobile technologies. Apart from these problems, some studies also reveal key best practices for supporting the implementation of mobile learning in computer science education. In the world of [32], there is a need for mobile learning experiences to be designed in a way and manner that captures collaborative, interactive and student-centered learning. This means that mobile devices are used to enhance peer-to-peer interaction, group work, and project-based learning. Furthermore, [33] posits that contextualizing mobile learning experiences is very important, including case studies, real-world examples and scenarios to illustrate key concepts and principles. Increasing students' motivation and engagement in academic activities is essential for educators to address to make learning more relevant and meaningful.

It is also relevant for educators to engage in good evaluation and feedback mechanisms regarding the use of mobile learning in computer science education [34]. This means that students' progress should be tracked using data and analytics. The literature review also showed the need to incorporate mobile technologies into the computer science education curriculum using pedagogical design and implementation [35]. To do this involves considering the learning content, outcomes and objectives in designing mobile learning experiences.

1.6. Justification for conducting an experimental study

Despite the widespread use of mobile technologies in education, there is a notable lack of experimental research on effective methods for implementing mobile learning applications in the training of future computer science teachers. Although numerous scholars have investigated mobile learning and the growing demand for computer science teachers, there remains insufficient experimental evidence assessing the effectiveness of mobile learning applications in the professional training of future computer science teachers, as well as a lack of guidance on the optimal methods for their implementation. While many studies have explored key benefits of mobile learning, particularly regarding accessibility and flexibility, to the researcher's knowledge, none have examined methods for implementing mobile learning applications in the training of future computer science teachers using the same content scope and methodology. This gap highlights the uniqueness and necessity of the present study.

2. Research method

This study used a pretest-posttest research design. This design consists of the control group and the experimental group. The study respondents were 100 students from L. N. Gumilyov Eurasian National University.

Pretest and posttest instruments were used in the study to determine respondents' knowledge and skills in computer science. Observation protocols were used to monitor mobile applications implementations, while surveys were used to examine how they perceived the intervention. The procedure started with a pretest, aiming to determine the skills and baseline knowledge of the control and experimental groups. Mimo, SoloLearn and Khan Academy are the mobile applications used through which the experimental group received an intervention. Mobile applications were not used in the control group.

They relied on the traditional teaching method. After the intervention, a posttest was administered to the control and experimental groups. The essence was determining their progress level and the effectiveness of integrating mobile learning applications. At the end, the researcher administered a survey to ascertain the perception of students regarding the intervention, as well as students' experiences with the use of mobile apps. In addition, t-test and percentages were utilized for data analysis. Also, tables were used to show the performance comparison.

3. Results and discussion

This section comprises five tables and two figures that show the analysis for the study. The average score was calculated as the sum of all scores received by learners in the group, divided by the number of learners. Standard deviation was measured to assess the variation of scores around the average value, which allows understanding how student results deviate from the average value. Data analysis showed that the experimental group's academic performance improved significantly compared to the control group. Table 1 shows that participants in the experimental group had a statistically significantly higher mean score than participants in the control group.

Table 1. Comparison of pre-experimental and post-experimental testing results

Group	Average score (before)	Average score (after)	Standard deviation (before)	Standard deviation (after)
Experimental Group	45	75	10	8
Control Group	45	60	10	11

The average score of students using the mobile application increased by 15% compared to the initial level, while in the control group, this indicator increased by only 5%. These results indicate a significant positive effect of using the mobile educational application on students' academic performance. Next, the data will be presented and compared on graphs, allowing for the visualization of the differences and analysis of the dynamics of changes in the preparation levels of students in both groups. Table 2 shows that participants in the experimental group had a statistically significantly higher mean score than participants in the control group.

Table 2. T-test analysis of the pre-experimental and post-experimental testing results

Variable	No	Mean	SD	t-value	df	Sig. (2-tailed)	α-level	R
Experimental Group	50	75	8	7.41	98	.001	0.05	Significant
Control Group	50	60	11	-	-	-	-	-

The ANOVA analysis in Table 3 reveals that the experimental intervention had a significant effect on the outcome variable.

Table 3. ANOVA analysis of the pre-experimental and post-experimental testing results

Source	Sum of Squares	df	Mean Square	F	Sig.
Between groups	5625.000	1	5625.000	54.883	.0001
Within groups (error)	10043.180	98	102.480	-	-
Total	15668.180	99	-	-	-

Figure 1 demonstrates changes in the standard deviation of student scores before and after the experiment in the experimental and control groups.

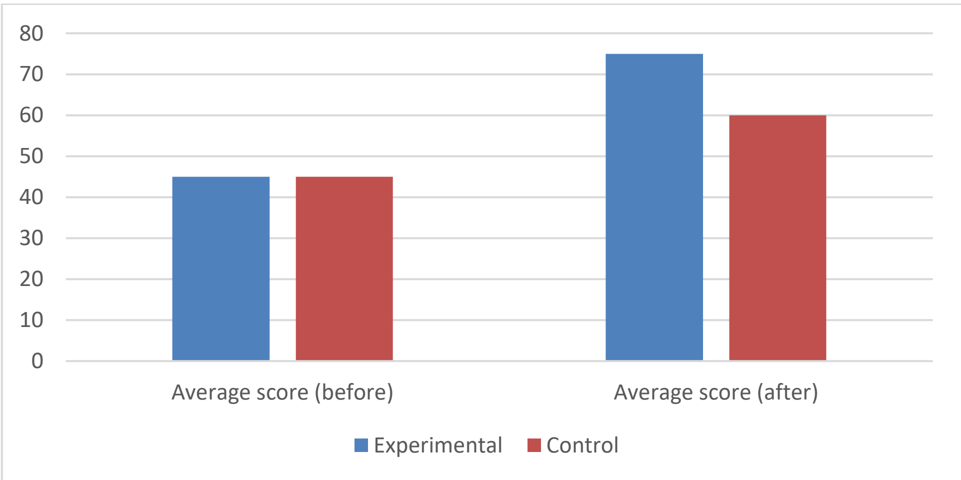

Figure 1. Comparison of average scores after and before the experiment in the experimental group and control group

Before the experiment, the standard deviation was the same for both groups and was 10 (Figure 2). After the experiment, the standard deviation decreased to 8 in the experimental group, indicating more homogeneous results and less score dispersion among students.

In the control group, the standard deviation, on the contrary, increased to 11, which may indicate greater variability in student results. The above graph is used to explain how consistency and uniformity of academic performance of students were affected using mobile applications.

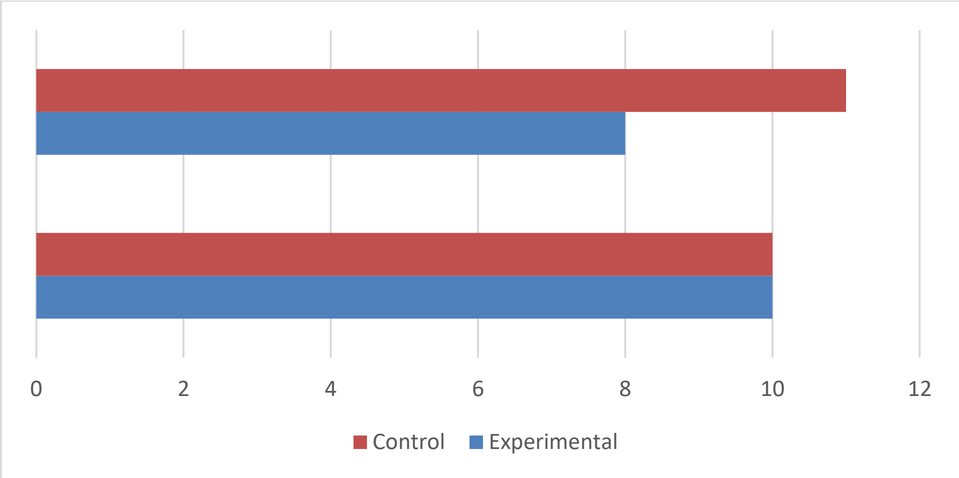

Figure 2. Comparison of standard deviation before and after the experiment in the experimental and control groups

Plotting the results on graphs enabled a visual comparison of performance gains and shifts in scores distributions for each group (experimental vs control). This visualization made it easier to see how the mobile application influenced the learning process.

Comparing data between the experimental and control groups confirmed a significant advantage of using interactive learning tools (Table 4). Data presented in Table 4 provides a detailed understanding of how students perceive the use of interactive learning tools in their educational process and their attitude towards these tools.

Table 4. Results of the student survey

Question	Very satisfied (%)	Satisfied (%)	Neutral (%)	Not satisfied (%)	Very unsatisfied (%)
1. How satisfied are you with the use of interactive learning tools in your educational process?	35	40	15	7	3
2. How much does using mobile game applications help you better absorb the educational material?	30	45	15	7	3
3. How often do you use interactive learning tools in the educational process? (daily, several times a week, once a week, less than once a week, never)	25	50	15	7	3
4. How much do interactive learning tools contribute to the development of your programming skills?	28	42	20	7	3
5. What types of interactive learning tools do you use most often? (mobile applications, web applications, virtual reality, other)	(100 mobile applications)	-	-	-	-

Question	Very satisfied (%)	Satisfied (%)	Neutral (%)	Not satisfied (%)	Very unsatisfied (%)
6. How easy was it for you to adapt to using mobile game applications?	40	35	15	7	40
7. How much does using interactive learning tools motivate you to learn?	35	40	15	7	3
8. What difficulties do you experience when using interactive learning tools? (technical problems, lack of instructions, low motivation, other)	25	33	17	5	10
9. How much do you think interactive learning tools improve your academic performance?	30	45	15	7	3
10. How would you rate the overall experience of using interactive learning tools?	35	40	15	7	3

The result showed a positive attitude toward the use of mobile game applications in the educational process. Teachers observed that the app greatly streamlined lesson preparation and delivery, letting them concentrate on instructional content instead of technical details (Table 5).

Table 5. Results of the teacher's survey

S/N	Questionnaire Items	Strongly Agree (%)	Agree	S/N	Question naire Items
1	I always assess interactive learning tools that are effective	27	63	4	6
2	Mobile game applications help me achieve educational goals	44	39	7	10
3	I use interactive learning tools in my classes	32	49	13	6
4	Interactive learning tools make teaching more flexible	41	48	5	6
5	It was easy to integrate mobile game applications into the educational process.	31	55	11	3
6	Interactive learning tools contribute to increased students' interest in the subject	38	59	2	1
7	I do not encounter difficulties when using interactive learning tools	43	46	9	2
8	Student academic performance improves through interactive learning tools	43	52	3	2
9	I utilize interactive learning tools during teaching practice	46	40	8	6
10	I recommend the use of interactive learning tools for every teacher	13	79	5	3

The data obtained confirmed the effectiveness of these approaches using interactive learning tools. This confirms the validity of using interactive mobile game technologies in education and the need for their integration into curricula (Table 6).

Table 6. Results of the teacher's survey

Criterion	Theoretical approach	Experimental data	Conclusions
Improvement in the quality of material absorption	The use of interactive learning tools suggests an improvement in the quality of material absorption	Students using mobile game applications showed a significant improvement in academic performance	The effectiveness of interactive technologies in improving the quality of material absorption is confirmed
Increasing the level of student motivation	Interactive tasks and game elements should increase student motivation	Students in the experimental group showed a high level of involvement and motivation in the educational process	Game elements contribute to active participation and the motivation of students
Development of key competencies	Mobile game applications contribute to the development of programming skills, logical thinking, and problem-solving	Students in the experimental group showed better results compared to the control group	Mobile game applications are an effective tool for developing key competencies
Validity of using interactive technologies	Interactive technologies should be integrated into curricula to improve the quality of education	The data obtained confirmed the need to integrate interactive technologies into the educational process	The validity of using interactive technologies in education is confirmed

3.1. Discussion

Ethical approval for this research was granted by the Institutional Review Board and this study captured all human-subject guidelines painstakingly. Voluntary participation and confidentiality were achieved because of the researcher sought the consent of the study participants. The results of this study indicated that there is a statistically significant different between the experimental group and the control group. The experimental group used the mobile app while the control group relied on the traditional methods. T-test analysis used in the study showed that the experimental group obtained more score that the control group in terms of computer science knowledge [36]

The findings showed that participants in the app group obtained a positive toward the use of mobile learning. There result noted engagement, flexibility and accessibility. These results align with findings from [37] and [1], which reported improved performance when mobile apps are integrated.

3.2. Implications for teaching practice and curriculum design

Mobile applications proved to be stronger tools for boosting teaching efficiency, so educators should embed them in mobile-learning process [38, 39]. Instructors ought to select apps that can strengthen learning outcomes by incorporating mobile learning from basic programming concepts to advanced topics [40] and by blending it with traditional methods to enhance flexibility and student involvement [41, 42].

3.3. Limitations of the study

The study involved 100 students from a single university, limiting generalizability. The short experimental period and the specific experimental period and the specific apps used may not represent the broader contexts.

4. Conclusions

A significant performance gap was observed favoring the experimental group. Students also showed a positive perception of mobile learning [43]. The research questions were answered:

1. Mobile learning apps significantly boost future computer-science teachers' academic performance.
2. Students view mobile app integration positively.
3. Mobile apps are an effective way to increase digital competence and engagement.

These results suggest teacher-training programs should include mobile learning in their curricula to equip educators with the skills needed for interactive and flexible teaching [44]. Based on the findings of the study, the following recommendations were made:

1. Teachers should embed mobile technology into curricula to ensure students have ample resources and practice opportunities for programming skills.
2. Educators should carefully select and implement mobile applications that align with the students' learning objectives to enhance student learning.
3. Educators should encourage students to use mobile applications so that students can have ample opportunities to practice their skills and the knowledge they acquired in computer science education.

Based on the data analyzed, future research must be carried out in the following areas and directions:

1. The impact of mobile technologies on teaching and learning in public secondary schools.
2. The same topic should be carried out using a larger sample size in another geographical location.

Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

The contribution to the paper is as follows: K. Berkinbayeva: study conception and design; K. Berkinbayeva: data collection; K. Berkinbayeva: analysis and interpretation of results; K. Berkinbayeva: draft preparation. All authors approved the final version of the manuscript.

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