Online-Journals.org

iJIM International Journal of Interactive Mobile Technologies

iJIM | eISSN: 1865-7923 | Vol. 19 No. 13 (2025) | OPEN ACCESS

https://doi.org/10.3991/ijim.v19i13.54947

PAPER

AI-Driven Personalized Mathematics Learning Through Interactive Mobile Platforms: Effects on Achievement and Motivation

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ABSTRACT

The increasing use of mobile learning platforms shows that people need adapted experiences that address mobile device features and system capabilities. This study evaluates the powerful effect that mobile learning environments enabled through artificial intelligence (AI) technology would have on mathematics education. The researcher adopted a quasi-experimental approach. The participants were randomly divided into two groups of eleventh-grade students. The findings revealed statistically significant differences at the significance level of (α = 0.05) between the mean scores of the experimental and control groups in the post-test, demonstrating the positive impact of an AI-based mobile educational platform in enhancing students' mathematics achievement. The finding confirmed that there are statistically significant differences at the significance level (a = 0.05) between the average ranks of the students in the experimental and control groups on the motivation instrument among high school students. Based on these findings, the study recommends implementing comprehensive training programs for teachers to ensure the effective integration of AI-based mobile educational platforms in the classroom. There is an immediate need for additional studies in this domain, particularly within high schools, to enhance the students' capacity for self-reliance in skill development.

KEYWORDS

artificial intelligence (AI)-driven personalized learning, mobile educational platform, mathematics achievement, motivation

1 INTRODUCTION

Artificial intelligence (AI)-powered personalized learning systems are transforming education. It delivers adaptive, learner-centered experiences. The intelligent systems process large datasets regarding student behaviors as well as assessment results and engagement patterns to design individualized learning pathways that

Alkhasawneh, S. (2025). AI-Driven Personalized Mathematics Learning Through Interactive Mobile Platforms: Effects on Achievement and Motivation. *International Journal of Interactive Mobile Technologies (iJIM)*, 19(13), pp. 33–54. https://doi.org/10.3991/ijim.v19i13.54947

Article submitted 2025-02-16. Revision uploaded 2025-04-29. Final acceptance 2025-04-29.

match different requirements and competencies of students because traditional education models do not consider unique student characteristics.

By continuously monitoring learner progress, AI systems provide timely interventions and targeted feedback to ensure support during challenging tasks and offer more advanced material when appropriate. Efficient response capability improves student motivation while simultaneously decreasing frustration, which leads to better learning efficiency [1]. The method of offering customized instruction works best for teaching mathematics because students need to develop basic knowledge before learning harder subject matter.

The platforms enable access to detailed information that guides educators toward making informed decisions. Currently employed analytics help teachers predict student insight patterns so they can make decisions based on data, which achieves better classroom management [2]. The adaptive procedures of assessment systems adjust their difficulty levels through student performance achievement to provide enhanced diagnostic measurement with quick support systems [3].

The enhancement of AI-generated personalized learning happens through its conjunction with mobile technology applications. Mobile technology creates better accessibility through which students can access content no matter what time or location they choose. AI-powered apps, such as intelligent tutoring systems, use mobile sensors and interaction logs to adapt tasks, deliver real-time feedback, and track learning trajectories [4], [5]. The platform's features generate richer student participation, particularly while students perform repetitive math exercises that need quick feedback support [6]. The merged system of AI with mobile and cloud platforms develops smart learning platforms that adapt to dynamic instruction designed for students, according to Papadakis et al. [4].

Instant adaptive feedback and corrections are provided through NLP capabilities in the Nerd AI application. Users continue using services after receiving motivational features that include gamified badges and push notifications via leaderboards. This helps boost participation levels. The mobile capability enables users to use camera-based OCR functions for equation entry, which desktop models lack. Innovative technology creates a dynamic learning environment that provides accessible and inclusive learning services to users.

Scientists will examine how effective Nerd AI is as a high school mathematics educational platform. The research examines mobile AI-driven personalized learning systems because they influence student academic performance together with their motivational levels. This study advances ongoing AI and mobile technology research in educational personalized learning because the combined use continues to be important for today's teaching systems.

1.1 Problem statement

Mathematics education throughout the world encounters continuous challenges regarding equality of opportunity together with achieving individualized teaching of high quality. Student academic performance declines when traditional education methods cannot adapt their learning approaches because math concepts prove challenging to learn. Education challenges intensify in developing areas because their minimal learning resources prevent them from adopting new student-centered educational practices. Smart devices have become a solution that helps to individualize education by enabling the downloading of applications to provide AI-based learning

experiences to a wider segment of students. This is due to the devices' widespread availability, low prices, and the emergence of numerous affordable devices that are accessible to everyone.

The mobile applications use AI technology to generate learning experiences according to individual student needs. The students receive immediate performance assessment through interactive problem-solving assistance, which allows them to resolve mathematical issues better and more adaptively. The lack of empirical research about AI-based mobile educational platforms exists despite their improved capabilities of boosting mathematics learning among students in settings with restricted access to quality educational content. This study intends to find out how AI-enabled mobile platforms can change the face of mathematics education through adaptive learning and sequential assistance since access to smartphones is becoming more universal to solve the digital divide in different learning contexts.

The study brings new knowledge about how AI-based mobile educational systems support students in their mathematical learning process and motivational behaviors through dynamic, customized, interactive lessons. The paper investigates the potential of AI-based solutions to scale up their operations and reduce costs for enhancing education access, specifically in areas with limited resources.

In this study, the empirical evidence of the integration of AI in mathematics education allows teachers and policymakers the opportunity to base their decisions. The research adds value to worldwide dialogues about how AI enhances educational transformation within various educational systems.

2 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Theoretical framework on personalized learning

Educational experiences under personalized learning become customized according to what students need and prefer as well as their specific learning development rates. Several pedagogical theories provide a foundation for this approach.

For instance, the Adaptive Personalization Theory of Learning (APTL) emphasizes tailoring learning experiences to individual learners' needs using AI systems that adapt based on real-time data. This theory involves learner-centric personalization, adaptive content, and continuous feedback, which enhances engagement and performance [7], [8].

Different educational theories validate the utilization of AI systems in teaching approaches. AI systems under the constructivism theory help students build knowledge by providing customized activities designed for their present cognitive development (Vygotsky, Piaget). AI systems that apply both rewards and feedback to students follow the behaviorist theory proposed by Skinner, according to Mayer [9]. AI systems based on the Cognitivism (Sweller) approach content adjustment to control what learners cognitively manage in their processing [10]. AI enables the support of social interactions and collaborative learning through its application of social learning theory proposed by Bandura. Part of the connectivism theory Siemens proposed learns best by forming connections between elements, which AI systems enable through their functions of creating expert networks.

The combination of AI-driven personalized learning integrates the theories of instruction to produce an interactive, learner-focused setting that enhances learning delivery while promoting student participation [11], [12].

2.2 Overview of AI-driven educational tools

Artificial intelligence has revolutionized the field of education by enabling personalized learning experiences. Several AI-powered educational tools operate in the education field to improve learning results through Nerd AI, Smart Sparrow, Knewton, and DreamBox as its main participants. The educational tool Nerd AI operates on mobile platforms to provide personalized learning alongside other tools that utilize cloud technologies and augmented reality, as discussed by [13]. The research relies on existing academic studies to assess educational platforms in terms of their features and limitations.

1. Nerd AI

   Nerd AI is a relatively new AI-driven learning platform that integrates machine learning algorithms to provide a personalized and adaptive learning experience. Natural language processing technology from NLP lets the system study student answers to modify how the learning sequence progresses automatically. The educational capabilities of Nerd AI look promising, but research-based evaluations about its effectiveness stand below those of more established platforms like Knewton and DreamBox [14]. Consisting of mobile usability and high school math focus differentiates the product, yet its long-term influence on student results and motivation needs additional experimental research.
2. Knewton

   Knewton was an early invention in adaptive learning platforms that obtained personalization outcomes from data analysis. Knewton provides individualized instructional content through its system of continuous student ability assessment [15]. Evidence reveals that Knewton's adaptive learning system enhances student retention combined with improved comprehension, which increases by 20% [16]. However, it provides a restricted learning environment, which may limit its accessibility and scalability in certain educational contexts.
3. Smart Sparrow

   The adaptive educational solutions provided by Smart Sparrow concentrate on dynamic feedback generation together with highly interactive educational experiences. Through combining student performance data, teachers can build personalized learning activities [17]. According to [18], students who learn with Smart Sparrow demonstrate improved engagement as well as higher motivation than standard online learners show. However, its reliance on instructor input for content creation can be time-intensive, potentially limiting its adoption in resource-constrained settings.
4. DreamBox Learning

   The educational program DreamBox utilizes AI-based technology to deliver mathematics studies for kindergarten through eighth-grade students. The system relies on live data analysis to modify problem complexity as well as create the most efficient learning routes [19]. A study proved that DreamBox Learning's program positively influences students' mathematical problem-solving skills, offering personalized and effective support for diverse learners [20]. However, its focus on elementary and middle school mathematics limits its applicability to older students or more advanced topics.

These mobile educational platforms show separate capabilities and limitations within their functionalities. For instance, the two platforms, Knewton and DreamBox, adjust educational pathways through real-time performance tracking metrics [16], but both systems have their drawbacks, as Knewton provides a restricted learning environment and DreamBox serves only younger learners. Smart Sparrow defines

itself through interactive functions and feedback mechanisms, according to [18]. The research shows students using these platforms outperform traditional methods of instruction because they obtain better retention rates and better performance [17], but they need extensive instructor involvement, which affects their potential for scalability expansion.

To conclude, each AI educational tool has specific strengths, but total success depends on how the material fits the students' needs together with their ability to stay interested and how easily the system adapts to different situations. Adjustments must be made to study how Nerd AI stands against other recognized education platforms in actual classroom settings. Empirical research would deliver expanded comprehension about the extended consequences that AI-driven learning systems possess on student academic development.

2.3 Overview of AI-driven personalization mobile educational platforms on students' mathematics achievement

Mathematics engagement is thus providing a new perspective in the age of AI. The mobile teaching platforms consider the AI algorithms to provide each student with a learning experience according to their needs, ranges of abilities, and styles of learning, eventually factoring into improved mathematics performance. AI-powered mobile platforms use machine learning and data analytics to analyze students' performance in real time, identifying strengths and weaknesses to provide customized learning pathways [21]. They adjust the level of problems in response to learners' current performance, help instantly, and suggest individual resources according to the moment-to-moment progress of students [22].

Machine learning and data analysis are the main features that AI-integrated mobile platforms use to observe and analyze students' behavior in real-time performance while determining the strengths and weaknesses for preparing personalized learning pathways [21]. Adjust these adaptive systems according to the learners—the level of difficulty in which questions get posed; they immediately provide all forms of assistance and recommend resources, which are made available to students based on real-time progress [22]. For instance, studies with middle school students in Karnataka, India, showed that students who learned through AI learning applications performed better than students experiencing conventional teaching [23]. Examples of AI-based adaptive learning technologies are Yixue Squirrel AI in China, which helps to improve the students' mathematics results because the content and difficulty level match the learner's needs [24].

Based on a research study, artificial intelligence-supported mobile platforms are quite efficient in producing students' mathematics improvements. Apart from giving feedback right away and suggesting the learning process in a more personalized pattern, mobile platforms equip students with better ways than traditional approaches to learning mathematics [25]. Furthermore, AI evaluation enables educators to determine student misunderstandings at the beginning, leading to prompt and more efficient action in teaching and learning and improving performance [26].

Scalability in Low-Resource Settings. It is now well-documented that AI-based tutoring systems work well across different education settings. AI-driven personalized learning platforms have proven effective in diverse educational contexts. For instance, [27] investigated the effect of an AI-powered conversational math tutor that is accessible via simple mobile devices. They reported substantial improvements in students' math achievement. They concluded that AI solutions can be used in such low-resource environments. The AI systems used in this process take student data

to determine the areas that students are struggling in and offer resources for learning that need to be filled strategically. Individualized instruction promotes learner activity by matching doing and communicating to the learner's needs and skill level. Students also get instant feedback from the AI platforms to address mistakes made, hence improving the learning process. Because the use of AI for student personalization is highly beneficial, there are common problems that are worth considering: data privacy issues, teacher training, and the lack of adequate access to technologies in certain populations of students.

In summary, the current use of AI in delivering personalized lessons in mathematics appears to reduce student failure and increase success rates. It remains important to support future research efforts and carefully apply this approach to identify and optimize its effects on relevant difficulties.

2.4 Overview of AI-driven personalization of mobile educational platforms on students' motivation

Many studies have proved that AI-driven mobile educational platforms improve students' motivation. Studies show that AI-self-administered learning environments provide personalized learning and a student's profile history, academic achievement, learning behavior, and preferred learning style. These systems improve student experience because such content can adapt to the student's learning and affective states to deliver better than the previously tended-to-poor retention rates [28]. Additionally, learning models that utilize AI have been found to enhance the involvement of students by targeting users' goals and needs generated by the algorithms that lead to increased student participation [29]. Additionally, the integration of AI-driven mobile educational platforms has been associated with improved study habits and time management among students, leading to increased motivation and better academic outcomes [30], [31]. The game elements of learning, AI-based tutors, and interactive problem-solving activities in a course are also strategies that a teacher can utilize to establish an engaging learning environment [32]. Similarly, it is possible now for students to get personalized learning through technology without the need to ask the teacher or confirm the details, and, at the same time, they will also be able to avoid any problem—frustration due to being wrongly judged—and thus lead to students being involved in appropriate tasks or inactivity because of cognitive overload [33]. Finally, [34] reported that AI-driven mobile educational platforms improve students' skills such as self-determination, motivation, and engagement.

When reviewing the previous literature, it has been noted that the growing interest in exploring the impact of AI-driven mobile educational platforms in developed countries. On the other hand, previous studies recommended investigating the effect of usability of AI-driven mobile educational platforms in different subjects and environments, especially in developing countries with limited resources. However, on the other hand, the researcher noted the scarcity of applied research in developing countries, even though mobile phones have become accessible to all students, through which we can download these applications.

This study builds a solid basis for AI-based mobile educational platform assessment by combining the theoretical frameworks mentioned with contemporary academic studies on student achievement and mathematics learning motivation. The study enriches academic research about AI by quantifying its effects on educational disparities and individualized education through evidence from a developing nation.

3 METHODOLOGY

Quantitative data was analyzed by the researcher under this category of research by using a quasi-experimental research method. This requires using two groups: the experimental group that was taught from the course using the Nerd AI app, is an AI virtual learning tutor that addresses subjects and learning needs, including solving math problems, writing assignments, language practice, summarizing information, and coding. It offers subsequent explanations on math assignments and other subjects, making learning more engaging and individual. It can also be used by students for purposes like carrying out creative writing assignments and coding activities, as well as general homework solutions. It also features AI-based quizzes and trivia games to enhance the level of content delivery. The control group was also taught the same content but without a Nerd AI app. To answer the study questions and achieve the objectives of the study, the researcher used the achievement test and survey because they offered a rich insight into the outcome of the study.

3.1 Participants

The research was conducted at a public high school in Amman, Jordan, due to its administration's willingness to support the research. All participants in the school belong to a single female student population, which follows a non-coeducational policy based on age (11th grade). The use of only female participants aligns with public school practices in Jordan because of their established segregation policies. The research design includes only females. This exclusive female research sample keeps findings from spreading to combined-gender educational scenarios, yet it enables solid control of documented gender differences in mobile learning outcomes. According to Iter and Salhab [35], in Palestinian higher education, female students utilize mobile learning platforms at rates 23% higher than male students ($p < 0.01$), which suggests that separate learning environments optimize mobile learning results because they remove gender-based motivational differences. Student placement into experimental and control groups occurred by class levels because this approach matched the operational needs of the participating schools. Two grade-level math classes participated in the study. A coin-toss method was used to randomly assign one class to the experimental group that received Nerd AI and the other to the control group that received the conventional method. The researchers did not apply pre-test score stratification or matching even though they verified pre-test result comparability through independent samples t-tests for baseline equivalence.

An assessment of students' mathematical achievements, digital abilities, and self-motivational rating occurred before the study to minimize the impact of confounding factors. The study checked all experimental variables' equivalence between groups before starting the intervention. The data analysis showed no significant differences between groups; therefore, researchers could attribute any post-intervention effects to educational intervention with confidence.

Before group assignment, researchers used independent samples t-tests to verify equivalence between groups on three crucial variables, such as 10th-grade final scores for mathematics achievement and pre-intervention digital literacy scores. The obtained results indicated no substantial disparities in all statistical tests (all $p > 0.05$); specifically, mathematics pre-test scores demonstrated exact equivalence throughout ($t = 1.287$, $p = .968$).

3.2 Instruments

This study used two instruments to elucidate executive effectiveness in fostering specific learning objectives for secondary school students. The subsequent phases outline the process for designing study tools:

Achievement test. Considering the study's methods, community, and objectives, the researcher developed an achievement test to assess learning outcomes. We developed the study tool through multiple phases until it became usable for pre- and post-testing of both the control and experimental groups. The tool's apparent validity was confirmed through content validity, and the judges' feedback was considered, leading to modifications and rephrasing of specific paragraphs. The reliability of the tool used in the study was assessed using the test-retest method. The test was applied to the same sample twice, with a time interval of ten days. The correlation coefficient was equal to 0.94, indicating that the tool has a high degree of reliability, thus its ability to provide consistent results over time.

The student motivation questionnaire. This study assessed students' motivation regarding instructional materials. The Student Motivation Questionnaire has 36 items in all. The IMMS is based on Keller's (1993) [36] ARCS Model of Motivation, which evaluates four key dimensions: attention, relevance, confidence, and satisfaction. These dimensions help determine the extent to which instructional materials engage learners and sustain their motivation throughout the learning process. [37] translated Keller's (1993) work and double-checked the translation was done. IMMS is the preeminent and dependable instrument for assessing students' motivation toward instructional materials and has been extensively utilized in various studies on student motivation.

The survey consists of 36 items rated on a Likert scale, allowing for a quantitative assessment of students' perceptions. To ensure the reliability of the instrument, the test-retest method was applied, with a correlation coefficient of 0.94, indicating strong consistency in responses. The IMMS was administered to both the experimental and control groups before and after the intervention, providing insights into the impact of the instructional materials on student motivation. The results contributed to understanding how AI-driven educational applications influence learners' engagement and motivation in instructional settings.

Integration of AI-driven personalized learning applications in mathematics lessons. The researcher used the SAMR model to incorporate Nerd AI into the teaching and learning of high school mathematics to improve and transform the education process through the purposeful use of specific mobile functionalities. The SAMR model, developed by Dr. Ruben Puentedura, categorizes technology use in education into four progressive levels, which comprise 1) substitution, 2) augmentation, 3) modification, and 4) redefinition. This framework then helps the educators with the evaluation and adoption of technology to supplement the teaching and learning activities [38].

1. Substitution: Students may utilize mobile OCR to interpret handwritten equations through their mobile camera, turning pen and paper inputs into digital data. The mobile app functioned as a replacement tool for standard hardware even though it maintained the same task requirements.
2. Augmentation: Real-time interaction features and step-by-step solutions, along with visual algebra tools that Nerd AI delivered through its mobile platform, made the system more powerful. The platform enabled students to achieve

superior mathematical conceptualization to static textbooks alongside standard calculators.

3. Modification: Students could solve problems together through mobile chat spaces for problem-solving while exchanging peer feedback through this platform, which made learning socially interactive across mobile access points whenever needed.
4. Redefinition: Mobile-specific features at Nerd AI include AI-powered tutoring alongside AR technology for 3D geometry visualization as the platform released new types of challenges that let users study spatial relationships through AR and resolve AI-based math problems within mobile contexts. Learning experiences enabled through mobile devices and AI that cannot exist outside of these conditions were incorporated into the Nerd AI platform.

The study utilized the SAMR model as a framework to illustrate how Nerd AI enabled advanced learning opportunities that increased student involvement and flexibility of learning environments along with cognitively engaged thinking.

AI algorithm transparency in Nerd AI. The system based on Nerd AI uses sophisticated machine-learning approaches to create personalized educational experiences for individual students. The platform adopts supervised learning models along with reinforcement learning models to examine student performance and automatically adjust learning courses.

Machine Learning Techniques: Nerd AI's AI algorithm depends heavily on supervised learning methods to review student information, including historical academic results, mistake detection patterns, and duration of activity. The largest datasets that training exposes the system to enable it to identify patterns and determine content that aids student advancement best. Student interaction with the application lets the system refine its predictions to modify exercise difficulty accordingly.

Decision-Making Processes: Within Nerd AI, decision-making proceeds from a collection of adaptive rules along with algorithms that drive operation. The AI system reviews both success accuracy and problem completion time after students resolve problems. Students who have trouble with a particular type of problem will receive additional practice materials from the system to strengthen that area of understanding. Nerd AI increases future problem difficulty after students master specific subject areas to maintain educational challenges but avoid overwhelming students. The system offers customized learning programs to students according to their specific educational requirements together with their learning speed.

Content Personalization Mechanisms: Content delivery through the Nerd AI platform receives individualization through an ongoing adaptive process that uses the feedback students generate. Through tracking student interactions, the application creates performance measurements for task completion statistics, time spent, and student errors made for adjusting learning materials. The system chooses exercise problems as designated from earlier interactions with students that target their specific knowledge gaps. The Nerd AI platform uses multimedia resources, which include step-by-step problem-solving guides as well as visual aids and style-based explanations for students. The approach delivers content that combines relevance with engagement to make students understand mathematics better. As shown in Figure 1, the procedure of AI Algorithm Transparency in Nerd AI.

Fig. 1. AI algorithm transparency in Nerd AI

Description of the Nerd AI-driven personalized learning system at math for high school level. Nerd AI serves as an effective mathematical platform that delivers customized, highly interactive, data-based educational experiences to students in high school mathematics. Through Nerd AI, students can understand mathematical concepts while receiving step-by-step solutions for problems, which also helps them monitor their educational advancement. To better illustrate the Nerd AI mobile application structure and vital features, this flowchart shows the user interface (UI) and main features. Figure 2 presents a flowchart outlining the user interface (UI) and key features, including adaptive learning paths, immediate feedback mechanisms, and content personalization options.

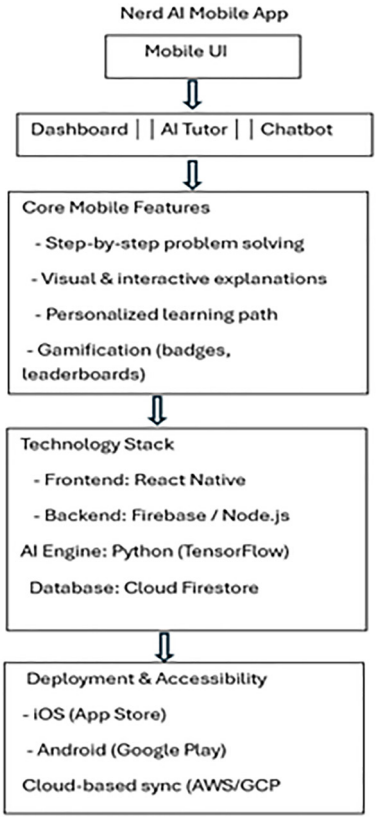

Fig. 2. Nerd AI mobile app: UI and features flowchart

The flowchart outlines the main sections, which consist of the dashboard, AI tutor and chatbot, interactive educational resources, and individual progress-tracking methods, and game-based mechanics. Multiple features in this application unite to offer students an adaptable learning environment that combines effective engagement features.

Because of this, the mathematical platform Nerd AI provides tailored educational encounters with high interaction levels to high school students. The implementation of AI technology delivers step-by-step problem solutions to students while helping them achieve deep comprehension of mathematical subjects. Students can monitor their academic development through the platform because it allows them to track their progress toward mastering mathematics skills.

1. Interactive Learning with Nerd AI: Nerd AI functions as an intelligent educational system that adapts the mathematics teaching format to individual student learning requirements.

A) Step-by-Step Problem Solving

Students can enter a math problem, and Nerd AI guides them step by step.

When students get confused Nerd AI provides guidance as well as complete step-by-step explanations to help them solve their problems.

Example:

A student needs to factorize $x^2 - 5x + 6$.

Nerd AI breaks it down:

Find two numbers that multiply to 6 and add to –5.

The numbers are –2 and –3, so the factors are $(x - 2)(x - 3)$.

If the student is confused, AI provides a different method or visual aid.

B) Visual and Interactive Explanations

Students find math easier using various graphical tools together with three-dimensional models along with animations.

AI automatically generates examples from geometry and presents explanations involving calculus and algebra.

Example:

The visualization of a moving graph demonstrates quadratic functions while students modify coefficients within $y = ax^2 + bx + c$.

2. Personalized Learning and Progress Tracking: The application adjusts individual student speeds and stores their assessment results.

A) Saves Student Performance Data

The system maintains detailed records about student problem completion together with their errors and areas of technical competence.

It generates progress reports showing:

Topics mastered

Areas needing improvement

Time spent on each problem

Example:

Students who need help with trigonometry will get more practice along with tutorial video recommendations before continuing to the next lesson material.

B) Personalized Study Plans

Students who commonly repeat mistakes enable AI to recognize recurring patterns, which improve their learning curriculum.

The system provides advanced concepts to help students to maintain their interest levels.

Example:

A student struggles with solving inequalities.

AI provides extra exercises and a different explanation.

AI progresses students from simple to more challenging subjects after they show improvement.

C) Predicting Student Performance

AI systems predict forthcoming obstacles through the evaluation of historical errors.

Educational programs identify when a student requires tutoring assistance prior to a test through automatic alert systems.

Example:

AI creates individualized revision strategies, which it provides to students before examinations.

Practice questions targeting weak areas

Timed tests to improve speed
Step-by-step solutions for difficult topics

3. Making Math Fun with Gamification: Nerd AI functions as a game system that delivers awards based on student academic advancement.

Studying challenging tasks enables learners to receive virtual badges from the system.

Leaderboards motivate them to improve.

AI provides its users with educational game puzzles and quizzes together with math games that function as rewards.

Example:

The student completes 10 complex algebra problems and receives the Math Master badge from the AI system and access to additional bonus content.

Conclusion

The platform of Nerd AI delivers math education and measures student development steps while organizing lessons to suit individual students and providing entertaining educational content. Through interactive tools and personalized study plans, and gamified content, Nerd AI enhances better student engagement while accelerating their educational advancement. The real-time feedback system of the platform enabled students to fix their errors right on the spot, while push notifications sent by the platform regularly prompted students to perform their tasks in a timely manner. The following Figure 3 shows a part of the Nerd AI in active use and how students interact with it in the real learning environment.

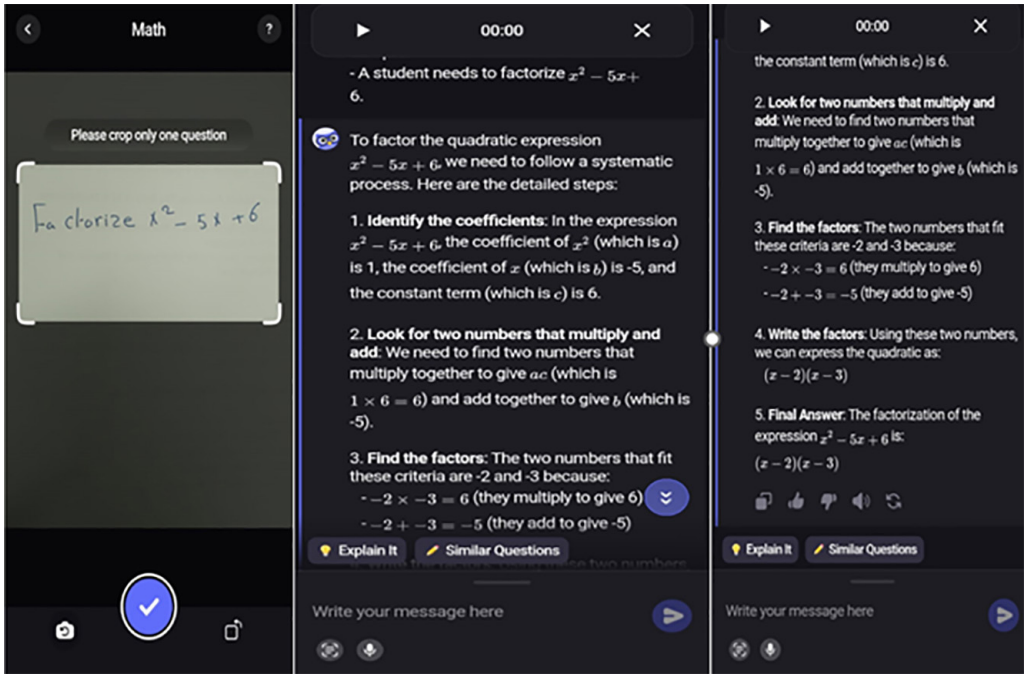

Fig. 3. Nerd AI: A snapshot of the mobile application in action

4 RESULTS

The first null hypothesis states: There are no statistically significant differences at the significance level (a = 0.05) between the average of the students of the

experimental (using AI-driven personalized learning systems) and control groups (without using AI-driven personalized learning systems) in the post-test.

The study employed analysis of covariance (ANCOVA) that used pre-test scores as a controlling variable for intervention evaluation. ANCOVA analysis was chosen based on three strengths that fit our Jordanian mathematics educational setting.

Afterward, ANCOVA was used to evaluate post-test results following pre-test adjustment. The methodology uses ANCOVA to eliminate any impact of prior academic differences between groups. The ANCOVA assessment proved valid because the study data satisfied its essential assumptions regarding data normality. ANCOVA provides an appropriate modeling approach for mathematics cumulative learning because it properly accounts for the systematic influence of prior knowledge, which remains vital to consider for Jordan's sequential curriculum. Before proceeding with the test, the researcher verified all necessary assumptions for ANCOVA analysis, such as normality and homogeneity of regression slopes and variance. Testing revealed normal distribution among residuals with no evidence of a covariate (pre-test scores) interaction effect with the independent variable (group assignment), thus authenticating ANCOVA as the appropriate statistical method for analysis.

4.1 Assumption testing and statistical analysis

The validation of the ANCOVA analysis required testing of multiple statistical requirements. The Shapiro-Wilk method checked the distribution norm. The data passed the regular distribution test for the experimental group ($W = 0.981$, $p = .142$) and control group ($W = 0.978$, $p = .117$) with non-significant results. This met the requirements for normal assumptions.

The analysis examined homogeneity of regression slopes through an assessment of the interaction between pre-test scores and intervention membership. The researchers verified that the relationship between pre- and post-test scores maintained consistency across all groups based on their findings of non-significance at $F(1, 58) = 0.451$, $p = .504$. The assumption of homogeneity among the groups was then evaluated to confirm their comparability regarding variance. Levene's Test was employed to verify that the observed outcome variations were not attributable to variability in group distributions, as illustrated in the table below.

Table 1. Levene's test for equality of variances

Groups	Mean	SD	T	P
Experimental group	.001	.004	–.077	.49
Control group	4.5	3.4		

Table 1 illustrates that there is no significant difference in the pre-test between the experimental group ($M = 6.55$, $SD = 2.24$) and control group ($M = 6.87$, $SD = .471$), $t(74) = .077$, $p = .49 > .05$. This result indicated the variances are equal across the groups (homogeneity of variance).

4.2 Statistical analysis

An analysis of covariance was conducted to evaluate whether the experimental group (using AI-driven personalized learning systems) had a higher achievement

test than the control group (without using AI-driven personalized learning systems) after controlling the effect of the pre-test. The post-test scores (refer to Table 2) showed a difference between the meanings in the post-test scores for groups. The means of post-test scores for the experimental group using AI-driven personalized learning systems were higher than the means of post-test scores for the control group without using AI-driven personalized learning systems.

Table 2. Adjusted and unadjusted group means and variability for post-test using pre-test as a covariate in the achievement test

		Unadjusted		Adjusted	
Groups	**N**	**M**	**SD**	**M**	**SD**
Experimental group	38	15.82	2.63	15.831	.32
Control group	38	9.97	3.89	9.94	.32

To reduce the statistical error, the pretest scores were used as the covariant, and a comparison was made between groups using the ANCOVA procedure (refer to Table 3).

Table 3. ANCOVA for the post-test scores as a function of groups using the pre-test as a covariant in the interpretive in the achievement test

Source	Df	Mean Square	F	Sig.	Partial Eta Squared
Pretest	1	510.3	136.6	<.001	.65
Groups	1	287.1	76.8	<.001	.20
Error	72	3.735			

The researchers performed an ANCOVA to evaluate the effectiveness of their AI-based intervention using pre-test scores as control variables after checking mathematical and normality conditions. The experimental intervention yielded significant findings according to the results, where $F(1, 72) = 76.8$ ($p < .001$) while achieving a Partial $\eta^2 = .20$ score for effect size. The pre-test scores showed a significant relationship with post-test results, $F(1, 72) = 136.6$, $p < .001$, leading to a large effect size (Partial $\eta^2 = .65$) that demonstrates why baseline achievement must be considered.

The mathematical achievement of students received a significant boost from AI-based mobile learning technology since their post-test scores reached 15.83 in the experimental group compared to 9.94 in the control group.

The medium effect size measurement ($\eta^2 = .20$) shows that AI personalization technology effectively enhances mathematics test scores at Jordanian secondary schools. Five and ninety-nine hundredths of a point improvement would elevate students from passing status (50–59%) to being in the good (60–74%) performance group, which is essential for STEM field university admission.

The second null hypothesis says, "There are no statistically significant differences at the significance level ($a = 0.05$) between the average ranks of the students in the experimental and control groups on the motivation instrument among high school students due to the use of AI-driven personalized learning systems."

The Mann-Whitney U test was used to compare the two groups for the variables that failed normality tests. The selected test proved appropriate because the Shapiro-Wilk test revealed the non-normal distribution of variables, which

disqualified parametric approaches like the independent t-test. The Mann-Whitney U test constitutes a solid non-parametric approach to evaluating differences between two independent groups.

The Mann-Whitney U test was used to determine the significance of the motivational differences between the experimental group (using AI-driven personalized learning systems) and the control group (not using AI-driven personalized learning systems); Table 4 presents the results.

Table 4. Mann-Whitney U test results for motivation levels between control and experimental groups

Groups	N	Rank Average	Sum of Ranks	U	P
Experimental group	38	44.99	1709.50	475.500	0.008*
Control group	38	32.01	1216.50		

Note: *The difference is highly appreciable since $p < .05$.

An examination of the findings in Table 4 shows that the results of the Mann-Whitney U test applied to the motivation levels of the students in the experimental and control groups revealed a statistically significant difference at the level of $p = .008 < .05$. The ranking average for the motivation level of the experimental group was 44.99, and for the control group, it was 32.01. The analyses revealed the rank mean of their motivation level scores, which indicated that the students in the experiment group had a higher motivation level than the control group students. The effect size, calculated as $r = 0.342$, indicates a medium effect, suggesting that the students in the experimental group had higher success after the experiment application than the students in the control group.

The moderate improvement in mathematics achievement ($\eta^2 = 0.20$) likely reflects the inherent challenges of math learning. The substantial rise in motivation achieved by students ($r = 0.342$, $p < 0.01$) probably came from their comfort with smartphone technology along with automated feedback provided by AI [39]. The prolonged implementation phase presents a genuine potential for improved results in both academic achievements and motivational factors.

5 DISCUSSION

This study shows that AI-powered educational software produces improved mathematics performance together with increased motivation for Jordanian high school students. Research findings agree with prior works that demonstrate AI systems outperform traditional educational methods through their findings [3], [28]. Nerd AI mobile generated student-focused learning programs based on individual ability levels to produce better mathematics results.

The system developed a better conceptual understanding by both implementing content adjustment based on learner progress and supporting the identification of required academic assistance. Studies confirm through their findings that individualized progress through adaptive educational software creates suitable learning environments that do not burden students [23], [25].

The advancement of student cognitive development and performance results from learning methods that use AI-enhanced personalization while being active and focused, according to [18] and [26]. AI technology, together with cloud-based smart

learning environments, allows teachers to obtain practical insights and students to advance their self-direction through improved assistance, according to Papadakis et al. [13], [42], when creating interactive digital content.

The study produced substantial improvements in student motivation as its primary result. The Nerd AI application immediately provided game-like feedback, which allowed students to track their improvement as well as receive adaptive challenges based on their achievements. The learning cycle enabled users to experience success and enhance their intrinsic desire to learn. Students remained active in the system because of badges, together with progress updates and interactive leaderboards.

The study confirms the principles of self-determination theory that describe motivation through three core variables, including autonomy, competence, and relatedness. Nerd AI delivers an adaptable learning space that facilitates student-paced education while delivering personalized instant support that promotes the three motivational factors. Research from [3] and [40] demonstrates that AI technology provides two major benefits to education through enhanced achievements in addition to creating learning settings that empower students.

This research shows that AI technology supports the elimination of learning achievement gaps because it responds effectively to the different learning requirements among students. The educational platform provided equal learning prospects to all students at whatever level they had reached, thus supporting problems common to underfunded educational systems. Cloud-based AI tools gain educational usefulness by developing scalable solutions that accommodate present educational systems, according to Papadakis et al. [13].

The accessibility features of the Nerd AI application served as a fundamental condition for achieving positive effects. Students could reach the Nerd AI platform through their basic smartphone devices because it needed only basic infrastructure that matched their existing technology. The implementation remained both cost-efficient and usable within schools that had minimal resources because of Nerd AI's mobile AI solution design element, which promoted accessibility to quality education.

Nerd AI included exclusive mobile features such as interactive task-solving capabilities alongside gamified mechanics and automatic feedback, which distinguished the platform from typical computer learning tools. The learning experience received support from push notifications and both 3D geometry visualizations and natural language processing functionality in the tutoring features. A study by Papadakis et al. [41] understands that mobile and AI system combinations will build the core components of future intelligent educational environments.

The study has a few limitations that must be considered. It relied on a small sample and limited geography. Research must examine how AI personalization in education influences mathematics success and student motivation through long-term duration while studying different educational zones. Researchers need to examine the extent to which cultural backgrounds, along with language diversity, affect the use of AI-powered tools across Jordanian geographical regions.

The research advances current studies about AI implementations in education through proof of mobile personalization systems, which boost educational success and student engagement. The findings underscore the need for further exploration into scalable, context-aware AI solutions that support diverse learners and promote equitable access to educational innovation.

5.1 Analysis of mobile-specific interactive features

The Nerd AI mobile platform used multiple interactive functions that enhanced student engagement together with learning outcomes. Gamification elements that incorporated badges and leaderboards turned out to be highly successful in motivating students to maintain their involvement. The system conducted push notification instances, which functioned as efficient memory triggers for practice duties, so students completed them each day. Real-time adaptive feedback mechanisms associated with each student's input delivery assisted them in finding proper solutions and strengthened their conceptual knowledge. The chosen design elements match the conclusions of [41] and [32] when they demonstrated how gamified mobile environments maintain student motivation as well as enhance their retention rates.

Usage pattern data revealed enhanced activity levels occurred right after gamified rewards were made available, which indicates these elements elevated student motivation to concentrate on the intervention activities. Research findings agree with student reactions to gaming elements where they experienced satisfaction upon achieving badges and making progress on leaderboards [42].

While no conventional usability tests were performed, it was possible to conclude from the students' and teachers' observational remarks and informal feedback that the mobile version of Nerd AI was quite popular for use beyond the traditional classroom setting. Students valued mobile platforms because they could adapt to their schedule by finishing tasks during transportation times or non-school periods when desktop use was impossible. The Nerd AI app demonstrated its responsive interface together with an intuitive design that made it possible for teachers to use it during lesson plans and homework routines.

The mobile Nerd AI version demonstrated enhanced accessibility since it performed better than standard desktop education platforms, especially when students lacked personal computers for study. Learning materials have become more accessible because of Nerd AI's ability to deliver education at any place and at any time. Students gained distinct capabilities through mobile platform features, including camera-based OCR, since it allowed for more efficient scanning of handwritten equations regardless of non-mobile devices. There are increasing demands for stronger AI and mobile-based smart learning platform integration within settings that lack educational resources [41], [42].

Mobile delivery of Nerd AI compared to web-based or traditional desktop learning tools had several advantages in both effectiveness and accessibility. The mobile nature of Nerd AI-enabled students to learn anywhere and anytime, which proved essential since it operated in regions lacking computer stations and dependable internet connections [41], [42]. Non-mobile platforms lacked both less efficient camera-based OCR technology and failed to offer real-time notifications. Mobile learning through this enablement boosted student encounters with educational materials while improving general learner participation within multiple educational environments [42].

6 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The study addresses various constraints before suggesting investigative paths for studying the effects and obstacles of AI-based personalized learning solutions.

An important drawback of AI-driven mobile learning involves limitations such as connection problems and hardware problems, as well as technology-related

interruptions that can interrupt student learning. The implementation of these factors produces implications for the uniformity and achievement levels in learning outcomes. Future studies need to locate methods that would improve mobile learning platforms' performance and interface throughout different technological settings.

The software designed to deliver customized education through AI systems retains biases that arise from the training data sources used. Such biases affect fairness together with the accuracy of recommendations delivered to learners. Future research should investigate methods to minimize algorithmic bias and maintain equitable student access to personalized learning paths.

There exists a lack of research about how AI-driven personalized learning affects student learning behaviors through time, especially for motivation, retention, and engagement. Future research requires long-term investigations that monitor how students develop their educational behaviors because of AI-based technologies, as it will help understand the lasting impact on academic results.

7 ETHICAL CONSIDERATIONS

The study obtained its official approval for ethics from the Research Oversight Committee at the Arab Open University Jordan School of Education (AOU-SOE-2023-20). The research ethics policy (AOU-VPAASR-AC-12(01)) of the Arab Open University received committee approval together with all procedures while adhering to ethical Declaration of Helsinki principles [43]. The review process recognized Category 2 settings of the university research framework because it incorporated minimal-risk educational methods and data deidentification for collection. The research falls under this classification because standard educational practices do not lead to participant harm or discomfort during the investigation. The committee approved the exemption rationale, which the committee documented officially in the letter of approval. Voluntary student and guardian consent involved written documentation before studying began. Participants received complete information about research aims and their freedom to participate without consequences or penalties, along with precise explanations of data protection procedures using coded information. A digital literacy evaluation of participants determined their functional capability with the mobile platform before study commencement. A combination of TLS 1.3 encryption protected the transmitted data, which the research team accessed exclusively through two-factor authentication from password-protected servers. All research procedures followed national requirements, which included Circular No. 5/2021 from the Jordanian Ministry of Education as well as relevant data protection legislation. Request the full ethical documentation at any time from the Research Office of the Arab Open University.

8 CONCLUSION

Using AI-driven personalized learning on mobile platforms in the education sector will change teaching and learning approaches and improve the students' achievement and motivation. AI technology can also be beneficial to learning environments because, using adaptive learning, it is capable of personalizing lessons to make them effective, exciting, and conducive to learning. In the consideration of using AI for computerized teaching and learning environments, some issues of

ethics need to be observed, and there is a need to involve the training of teachers. This transformation of the educational process, identified through analyzing the effects of the application of AI on students' achievements, proves that AI brings change with the help of customization. This means that AI integration can completely revolutionize how people learn and use knowledge if only technological advancement continues. Such a shift has profound implications concerning the students, practical functions of tutors, and in general, the character of education, which is not simply an upgrade of the technological kind. Technological integration, especially using artificial intelligence, applies complex processes in organizing the education process based on a student's needs, preferences, and achievements. It encourages interaction, fosters understanding of the subject matter, and allows the students to tap into any information that they find relevant. Concerning the role of AI systems, it means that the educational process can be learner-focused, dynamic, and personalized because the system can assess the interactions and progress of the learner and advise on an individual learning path, present the materials immediately, and provide feedback as well. Using AI-driven learning platforms to attain higher skill levels, students have control over their learning process. Additionally, the incorporation of AI avoids reliance on equally conventional forms of learning and teaching, which creates equitable opportunities for all learning abilities. On the other hand, there are challenges such as algorithmic biases and data security concerns, and the limitations of current AI systems must be addressed to maximize the effectiveness and equity of personalized learning. There is a great need for more research to examine how AI influences student performance and motivation on the long-term impact. Additionally, research should study how these instruments function in various multicultural and diverse economic situations. The evaluation of Nerd AI needs comparison studies regarding two alternative platforms, Smart Sparrow and DreamBox, to identify what makes Nerd AI exceptional and where it faces challenges. Future research should examine how AI-driven platforms affect the development of critical thinking along with problem-solving abilities at high cognitive levels. Future research focused on these areas will help develop better AI-driven educational solutions that fully empower the use of AI in education. The success of AI-driven mobile education demands all stakeholders to work together to develop inclusive and ethical systems that create premium-quality personalized learning. A revolutionary role in changing mathematics teaching and learning success throughout digital society becomes possible through sustained innovation and the resolution of these platform obstacles.

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