

PAPER

Enhancing Mobile Learning with AI-Powered Chatbots: Investigating ChatGPT's Impact on Student Engagement and Academic Performance

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ABSTRACT

In mobile learning environments, after-class review strategies play a crucial role in reinforcing key concepts, summarizing knowledge, and enhancing subject mastery. However, students often encounter difficulties reviewing lessons due to limited support and immediate assistance, impacting their overall learning experience. This study examines the role of artificial intelligence (AI)-powered ChatGPT as a mobile learning tool to support pre-service students in academic performance, cognitive load reduction, perceived learning, trust, and motivation. Utilizing a quasi-experimental design, two classes enrolled in an assessment and evaluation course at UTM University, Malaysia, participated in the study. The experimental group (n = 16) engaged with ChatGPT via mobile devices for post-lesson reviews, while the control group (n = 16) relied on traditional instructor-led interactions. Pre- and post-tests and ANCOVA analyses were conducted to evaluate changes in students' learning outcomes. The findings indicate that mobile AI-powered ChatGPT significantly enhances academic achievement, reduces cognitive load, and fosters increased motivation, perceived learning, and trust. The results highlight the potential of integrating AI-driven mobile learning solutions to provide personalized, on-demand academic support, enabling students to engage in more effective and flexible learning experiences beyond traditional classroom settings. These insights contribute to the growing body of research on AI in education, emphasizing the need for further exploration into mobile AI-driven interventions for diverse learning contexts.

KEYWORDS

mobile learning, artificial intelligence (AI), ChatGPT, academic feedback, academic achievement

1 INTRODUCTION

Artificial intelligence (AI) has recently become a powerful force that has changed many areas, including education [1]. It has much potential to help with global problems

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and create education opportunities. AI has improved access, quality, fairness, personalization, and lifelong learning, creating more inclusive learning spaces [2]. AI usage in education involves many aspects, such as adaptive learning, personalized teaching, developing metacognitive skills, improving critical thinking, creating a curriculum, lesson planning, and assessing the student's performance [2], [3]. Teaching metacognitive skills is looked at through AI tools to create flexible and personalized content to suit an individual's learning style [3]. These tools are very important in helping students with different needs, such as various learning styles and disabilities [4].

Review and feedback are the most basic learning process stages that help students achieve mastery over the knowledge gained. Students' achievement is predominantly a result of mastering content in some way. Its three main goals are strengthening learned knowledge, clarity about significant topics, and excellence in learning effectiveness. According to the constructivist perspective, learning is perceived as a mental construction where learners assimilate new information into existing knowledge, fostering active understanding [5]. In the post-class review phase, teachers assume the role of learning facilitators, employing diverse strategies to augment students' learning outcomes [6], [7]. A study by Lee et al. [8] indicates that students risk forgetting approximately 42% of learned content without adequate review within 20 minutes of class. Consequently, reviewing on time following lesson teaching is deemed essential for knowledge memory.

Notwithstanding its importance, educators have observed that students refrain from asking questions, whether in class or during post-class review, for various reasons. Students, in particular, exhibit shyness in posing questions, often stemming from a lack of confidence, communication difficulties, and a fear of being perceived negatively for asking seemingly simple questions. This reticence challenges instructors to provide effective feedback during the review process. Research highlights that the feedback given to students during lesson teaching is frequently inadequate in terms of quality and quantity [9]. Adopting modern technology to address this challenge and facilitating a more effective after-class review is imperative. Incorporating technology aims to enable students to receive prompt and high-quality feedback, enhance their motivation to learn, and reduce their ongoing knowledge construction [10].

One of the main applications is using ChatGPT as an instructional technique, referred to as a scaffolding tool. This AI tool guides students and teachers in providing critical support for lesson plan development, activities, and worksheets [11]. Another application of AI is searching for engines that help find the correct information for academic purposes, such as lecture preparation and literature reviews. The capability of AI to condense extensive content into concise forms, along with its application in assessment and deflection, underscores its considerable potential in educational settings [12]. ChatGPT, an AI software utilizing "semantic analysis" and "natural language processing (NLP)," engages in voice and text conversations. This technology comprehends user prompts, creating an interactive experience with defined sentences and offering personalized applications [13]. ChatGPT is applied in education, research, data analysis, healthcare, customer service, and tourism [1], [2], [8]. The response speed ability of AI-powered ChatGPT has attracted educators, especially in education, for instance, language learning [1], [14]. These AI chatbots are of great value as alternatives for all-time, all-places learning because they offer language exercises with short feedback for students. AI-powered tools, particularly in primary education, have shown promise in enhancing student engagement, cognitive development, and interactive learning [15]. These technologies support the constructivist

and experiential learning models, enabling students to apply AI concepts in various subjects, including STEM and language learning [16].

Mobile learning has gained significant traction due to the increasing reliance on digital tools in education. Integrating AI-powered applications such as ChatGPT into mobile learning environments enables students to access learning resources anytime and anywhere [11], [17]. Mobile AI-powered learning offers personalized, interactive, and on-demand education, enhancing student engagement and participation [12]. ChatGPT applications used on mobile devices provide instant responses to students' queries, fostering a dynamic and self-paced learning environment. This shift towards mobile-based AI learning bridges the gap between traditional and modern digital education, making learning more accessible and effective [13].

Students widely appreciate the accessibility of ChatGPT, which meets their requirements [18]. Chatbots contribute to a student-centered learning environment by offering relaxing and friendly interactions [19], [20]. In pre-service education programs, which cover subjects such as education, psychology, teaching methods, curriculum development, and various subject teachings, students often require extended knowledge and practical experience. Dissatisfaction with traditional education courses has been noted, emphasizing the importance of clarifying doubts during course reviews [8], [21]. Timely resolution of problems in class is necessary, as unresolved issues may impede the mastery of prior knowledge and hinder learning new knowledge [22]. In addition to providing textual support, ChatGPT on mobile platforms incorporates interactive features, including voice-enabled responses and multimodal content delivery [23]. These features enhance student engagement by allowing learners to communicate through text and speech, making the learning process more immersive and interactive [14].

An application utilizing ChatGPT via a mobile platform for professional content was employed to bridge theory and practice in the curriculum. This study investigates the effects of using ChatGPT on mobile devices to review pre-service students' academic performance, motivation, and attitude in the education curriculum. The extended dialogue and immediate responses offered by ChatGPT using a mobile phone will be expected to enhance learning outcomes [24].

This study investigates mobile AI-powered ChatGPT's impact on academic performance, cognitive load, perceived learning value, perceived trust, and learning motivation in pre-service students. The main objectives of the studies are 1) To assess whether mobile AI-powered ChatGPT enhances students' academic performance more effectively than traditional after-class reviews. 2) To explore the influence of ChatGPT usage through mobile applications on students' cognitive load, perceived learning value, perceived trust, and learning motivation compared to conventional after-class review approaches. Furthermore, these main objectives aim to evaluate the comparative effectiveness of ChatGPT against traditional after-class review methods in improving academic performance and enhancing different aspects of the learning experience, including cognitive load management, perceived learning value, trust, and motivation.

2 LITERATURE REVIEW

Lavidas et al. [25] highlighted that students' adoption of AI applications in higher education is influenced by various factors, including their expectations of performance, habitual usage, and perceived enjoyment. As AI continues to evolve, its applications in education have expanded, enabling multimodal content generation

across text, images, and videos. AI tools such as ChatGPT, CoPilot, Stable Diffusion, and DALL-E provide students with personalized learning experiences, tailored feedback, and enhanced access to information. Particularly in higher education, AI supports language translation, research facilitation, data analysis, and academic decision-making, making it a valuable tool across various disciplines, including humanities and social sciences. Reviewing plays a critical role in learning by strengthening retention and knowledge retrieval. Successful review activities include encoding, storing, and retrieving information to enhance short-term and long-term memory. Short-term memory is a temporary cache, whereas long-term memory requires frequent engagement to maintain retention [26]. Post-lesson reviews aid learners in determining principal concepts, knowledge summarization, and consolidating newly gained perceptions with previous learning, strongly impacting academic performance [27]. Reviewing is beneficial after lessons and before learning new content, allowing learners to relate former knowledge to future learning. Successful review tactics, including exam worksheets and short-answer tests, strengthen memory retention and problem-solving skills. Additionally, systematic review systems have enhanced students' assessment performance [28]. Lack of feedback may infuriate learners and prevent mastery of current and new knowledge [29].

Recent AI developments have brought tools such as ChatGPT, which provide revolutionary solutions to improve post-lesson feedback and review. ChatGPT, created by OpenAI, assists learners with personalized interactions, question generation, and content summarization [30]. This AI tool solves issues in conventional classrooms, such as limited time for individualized feedback, by providing effective, interactive, and easy-to-use assistance [31]. It allows students to review lessons, break down key points, and solidify their knowledge, leading to better learning outcomes [32]. Almogren et al. [11] highlighted that mobile AI-powered learning systems enhance accessibility and engagement, enabling students to interact with ChatGPT seamlessly through smartphones and tablets, fostering continuous learning beyond traditional classroom settings. ChatGPT is universally accepted as a time-saving and effective learning tool. Perceived learning value is critical in students' behavioral intentions in learning environments [33]. A study emphasized that practical tools build students' confidence and interest, especially when such tools enable the acquisition of knowledge, save time, and match learning objectives [34]. Chatbots like ChatGPT are now central to education, providing interactive, context-sensitive information and support that stimulate learner engagement and enhance perceived value. Research indicates that students view ChatGPT as an important learning tool, especially for individualized learning and understanding intricate topics [12], [35]. Foroughi et al. [36] showed that Malaysian learners who employed ChatGPT exhibited greater satisfaction and perceived learning value. Yang et al. [37], however, warned against excessive dependence on AI, citing the need for balancing active learning and autonomous knowledge acquisition.

Perceived trust is central to learning technologies, particularly AI-based tools such as ChatGPT. Trust determines user engagement, satisfaction, and the effectiveness of learning technologies [38]. Studies indicate that students who trust ChatGPT are more likely to perceive it as a trustworthy learning tool, improving their engagement and willingness to use it [39]. This is consistent with the Self-Determination Theory, which suggests that autonomy, competence, and relatedness enhance intrinsic motivation [40]. In learning environments, perceived trust includes confidence, reliance, and technological assurance. Students who trust ChatGPT for feedback and personalized learning are more inclined to seek help and participate in interactive learning activities. Nevertheless, overdependence on AI can compromise

critical thinking and independent problem-solving, highlighting the importance of a balanced approach.

Motivation is central to academic achievement, influencing students' interest and perseverance in learning experiences. ChatGPT can boost learning motivation by stimulating curiosity, instant feedback, and adaptive learning experiences [43]. The instrument is consistent with "Self-Determination Theory by inducing autonomy, competence, and relatedness" to foster intrinsic motivation [41]. Research conducted by Yilmaz and Yilmaz [42] has indicated that ChatGPT minimizes cognitive load and enhances comprehension of complicated concepts, thus motivating students. Additionally, Abdelghani et al. [43] discovered that the tool positively impacts the question-asking ability and widens the learning experience horizon. Moreover, integrating mobile AI-powered learning enhances motivation by offering real-time assistance and personalized feedback anytime and anywhere, reinforcing self-regulated learning behaviors (Chen et al., 2023).

Assessing academic achievement involves evaluating the effectiveness of educational interventions, such as ChatGPT, in enhancing students' knowledge and skills. AI chatbots such as ChatGPT positively impact academic performance, including enrollment processes, personalized learning, and interactive teaching [44]. In higher education, ChatGPT facilitates personalized feedback, aids in data analysis, and improves student engagement in research and assignments [45]. Studies indicate that AI-driven tools enhance students' understanding and retention of complex concepts, leading to improved academic outcomes. Mobile AI-powered learning solutions strengthen academic performance by providing on-demand access to educational resources and AI-driven tutoring systems that adapt to individual learning styles [46], [47]. Research at Georgia State University demonstrated conversational AI systems improved pre-enrollment outcomes and timely enrollment [48].

This study aims to provide empirical evidence on the impact of ChatGPT on students' academic performance and its implications for educational practices. Further research questions of the studies are as follows:

- RQ1: How does the use of mobile AI-powered ChatGPT impact the pre-service students' academic performance after the post lesson?
- RQ2: What is the cognitive load experienced by pre-service students when engaging with ChatGPT in a mobile learning environment?
- RQ3: How do students perceive the learning value derived from the experience of using ChatGPT in mobile learning environments?
- RQ4: To what extent does students' perceived trust contribute to the effectiveness of mobile AI-powered ChatGPT in facilitating learning review and feedback?
- RQ5: How does using mobile AI-powered ChatGPT impact pre-service students' motivation to learn?

3 RESEARCH METHODOLOGY

3.1 Research design

This study employed a quasi-experimental research design, utilizing a pre- and post-test framework. The participants included two classes enrolled in an "assessment and evaluation course" at the School of Education at UTM University, Malaysia. The experimental group comprised 16 students (six males and 10 females), while the control group consisted of 16 (eight males and eight females). The experimental group utilized

mobile AI-powered ChatGPT for course review and feedback after lesson delivery, while the control group worked with the teacher directly. All students were instructed by the same educator with over eight years of teaching experience. We utilized only the achievement test to gauge the learning performance before and after the experiment for both groups and compared their performance. In addition, we obtained perceptions from participants using a questionnaire based on well-established research constructs, employing a 5-point Likert scale. These constructs included Cognitive Load, Perceived Learning Value, Trust, and Learning Motivation. We adopted research items from existing literature, piloted and revised the questionnaire based on feedback, and administered it before and after the experiment. Subsequently, we analyzed the survey data to understand participants' perceptions, attitudes, and feelings.

3.2 Ethical approval statement

The study was conducted in accordance with ethical standards. Ethical approval was obtained under Reference No. RMC/Q.J130000.21A2.07E10, with formal permission granted by Universiti Teknologi Malaysia (UTM) through Letter Reference No. UTM.J.13.01/13.14/1/88 Jld.23(75), dated June 1, 2023, under the RMC research project No. Q.J130000.21A2. Written informed consent was secured from all participants, ensuring they were aware of data usage (e.g., scientific publication) and their rights regarding identifiable personal data. Participants were assured of confidentiality and the voluntary nature of their involvement in the study.

3.3 Survey questionnaire

This study examined four key factors: 1) cognitive load, 2) perceived learning value, 3) perceived trust, and 4) learning motivation. Our validation process involved expert review, pilot testing, and statistical analysis. Initially, draft questionnaires were scrutinized by subject matter experts for clarity and relevance. Then, our pilot testing with a similar sample further refined the items. Pilot test results have shown that the cognitive load factor, assessed through six items, exhibited a solid internal consistency with a reliability coefficient of .85 [49]. Similarly, the perceived learning value factor, consisting of six items, demonstrated a commendable level of reliability with a coefficient of .89 [49]. The perceived trust factor, comprising five items, displayed a high level of reliability with a coefficient of .88. Finally, the learning motivation factor, assessed through seven items, demonstrated a robust internal consistency with a reliability coefficient of .90. These high-reliability coefficients across all factors indicate the consistent and dependable measurement of cognitive load, perceived learning value, perceived trust, and learning motivation within the scope of the study [49]. These findings strengthen the study's credibility and validity, laying the groundwork for interpreting and discussing how these elements affect technology user intent. These verified surveys provide a solid framework for studying how cognitive load, learning value, trust, and motivation affect education technology usage.

3.4 Achievement test development

The primary goal of the achievement test was to assess if there was a disparity in instructors' learning results before and after training. The accomplishment exam

was developed with the assistance of test development professionals, who used a table of specifications (ToS) that considered the instructional content. Subsequently, the researcher meticulously examined, rectified, and eliminated some elements in the comments provided by the reviewers, including their input and ideas. As a final iteration of the exam, the researchers developed a 35-item achievement test. This test was pre-tested on 15 students to ensure validity and reliability. The statistical analysis in this study was conducted using the "Test Analysis Program (TAP) program" [7]. As a result of the inadequate distinctiveness of the items, five items were excluded from the test. The 23-item KR-20 test had a reliability coefficient of 0.86, close to 1. This suggests that the test is very dependable and may be considered trustworthy. The uniqueness index of the test items was found to be very satisfactory (0.49); however, the difficulty level of the test items was supposed to be moderate (0.63) [50].

The main objective of the achievement test was to evaluate whether there was a difference in instructors' learning outcomes before and following training. The accomplishment test was constructed with the help of test development experts, who utilized a table of specifications (ToS), considering the instructional material. Then, the researcher carefully reviewed, corrected, and removed some aspects of the reviewers' comments, including their suggestions and ideas. As a final draft of the exam, the researchers constructed a 35-item achievement test. This test was pre-tested on 15 students to confirm its validity and reliability. The statistical analysis of this study was performed using the "Test Analysis Program (TAP) program" [38]. Due to the insufficient distinctiveness of the items, five items were removed from the test. The 23-item KR-20 test had a reliability coefficient of 0.86, close to 1. This indicates that the test is highly dependable and can be deemed trustworthy. The uniqueness index of the test items was very satisfactory (0.49); however, the difficulty level of the test items was considered to be moderate (0.63) [39].

3.5 Experimental procedure

The experimental procedure employed in this study adhered to a quasi-experimental research design to assess the effectiveness of mobile AI-powered review activities among students enrolled in an education program course, with mobile-powered ChatGPT utilized in the experimental group. Before the experiment commenced, a 20-minute pre-test achievement test was administered to all participants, alongside survey questionnaires, to gauge perceptions related to cognitive load, perceived learning value, perceived trust, and learning motivation factors. Following this, an hour-long orientation session was conducted for teachers paired with mobile AI-powered ChatGPT, covering its usage, limitations, and applications in teaching, ensuring experimental integrity. The course spanned two weeks, with weekly sessions lasting 60 minutes each. The curriculum focused on Bloom's Taxonomy, addressing lower-order thinking skills in the first week and higher-order thinking skills in the second week. Both experimental and control groups received lessons from the same teacher. During review sessions, the experimental group utilized mobile AI-powered ChatGPT alongside worksheets provided by the teacher, with students interacting with ChatGPT to solve tasks related to Bloom's Taxonomy levels. Additionally, they could contact the teacher via WhatsApp for clarification. Conversely, the control group engaged in traditional interactive review sessions, reviewing course material and completing worksheets with the teacher's assistance.

After each class, students from both groups were assigned 10 task worksheets related to the week's content, with task records meticulously maintained. Upon completing the course, a 20-minute post-test achievement test and survey

questionnaires were administered to assess changes in learning achievement and perceptions of cognitive load, perceived learning value, trust, and motivation factors. See Figure 1 to understand the experimental procedure we adopted for this study. Data on student performance, interaction with mobile AI-powered ChatGPT, and teacher-student communication were recorded for analysis, facilitating a comprehensive evaluation of the intervention’s impact on learning outcomes and review processes.

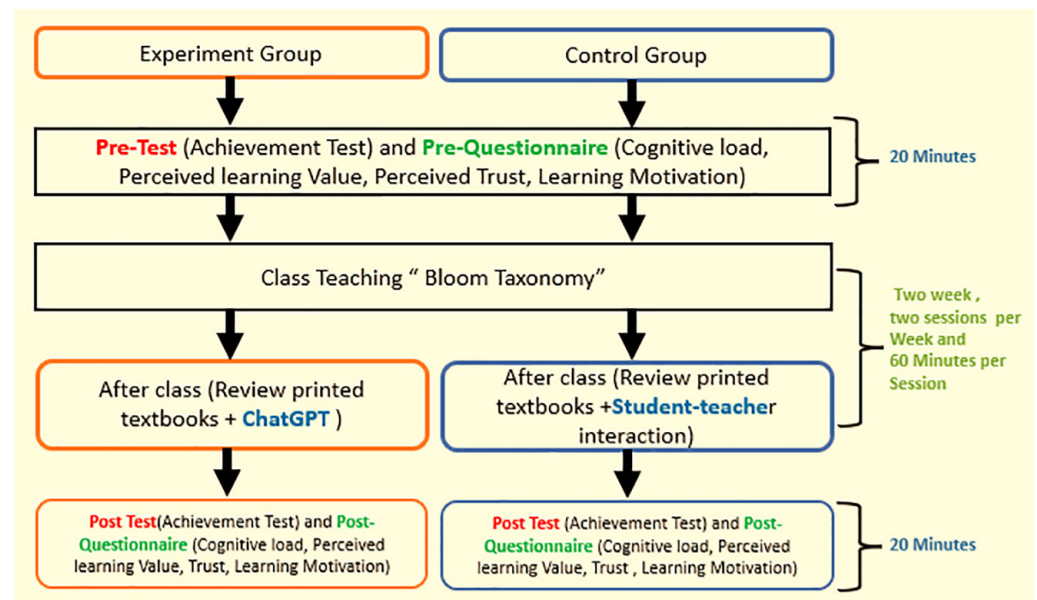


Fig. 1. Experiment design

4 RESULTS

4.1 Demographic data analysis

The study’s sample included 32 university students selected from the school of education department. Table 1 provides data on the demographic features of the sample. The experimental group consisted of 16 students, with six males and 10 females, selected randomly. In contrast, the control group consisted of 16 professors, with an equal distribution of eight male and eight female pupils.

Table 1. Distribution of population-based on gender and group

	Group	N	Male	Female	Total
Distribution	Experiment	16	6	10	32
	Control	16	8	8	

4.2 Analysis of academic achievement test

To compare the academic achievement test, an independent samples t-test was used to investigate the effect of mobile AI-powered ChatGPT on academic achievement as captured in pre-test and post-test scores for an experimental and

control group, as indicated in Table 2. During the pre-test stage, no significant difference was observed in the mean scores between the experimental group ($M = 17.438$, $SD = 4.320$) and the control group ($M = 15.688$, $SD = 5.069$), $t(30) = 1.051$, $p = .302$, indicating similar academic performance prior to intervention. After applying mobile AI-powered ChatGPT, a clear divergence in post-test scores occurred. The experimental group had a significantly higher mean score ($M = 28.313$, $SD = 1.922$) than the control group ($M = 23.313$, $SD = 3.995$), $t(30) = 4.511$, $p = .000$. This result highlights the positive effect of mobile AI-powered ChatGPT on academic achievement, as supported by the high difference in post-test scores between the two groups. This differs from the significant value of 0.05 [51]–[54].

Table 2. Achievement test (independent sample t-test)

Test	Group	N	Mean	Std. Deviation	T	Df	Sig
Pre-Test	Experiment	16	17.438	4.320	1.051	30	.302
	Control	16	15.688	5.069			
Post-Test	Experiment	16	28.313	1.922	4.511	30	.000
	Control	16	23.313	3.995			

4.3 Effect of ChatGPT on academic achievement

An achievement test was conducted before and after the experiment to determine the difference between both groups to assess the effectiveness of mobile AI-powered ChatGPT within groups. To find the key difference between learning achievement in both groups. The experiment group engages with mobile AI-powered ChatGPT, and the control group does not engage with such interaction. Descriptive statistics in Table 3 indicate that the Experimental group, with a mean score of 28.31 ($SD = 1.92$), surpassed the Control group, with a mean score of 23.31 ($SD = 3.99$). This initial observation suggests a potentially positive influence of ChatGPT on learning outcomes. We employed the statistical test; the univariate analysis of between-subjects effects revealed a statistically significant impact of the learning intervention on post-test scores ($F = 11.446$, $p = .000$, $\eta^2 = .441$). The substantial effect size ($\eta^2 = .441$) underscores ChatGPT's meaningful contribution to the observed variance in learning achievement [8], [55]. This consistency supports the notion that mobile AI-powered ChatGPT exerts a positive and influential effect on learning achievement. This finding is particularly relevant for educational contexts seeking innovative ways to enhance the learning experience. Integrating mobile AI-powered ChatGPT in the learning process has demonstrated a statistically significant and positive impact on learning achievement, as evidenced by higher mean scores in both groups. The consistently adjusted means and effect sizes further reinforce that mobile AI-powered ChatGPT has influenced participants' learning outcomes. This analysis aligns with current research emphasizing the potential of mobile AI-powered interactive technologies in educational settings to enhance student learning.

Table 3. Univariate analysis results (academic performance)

Test	Group	N	Mean	Std. Deviation	F	η^2	Sig
Achievement Test	Experiment	16	28.31	1.92	11.446	.441	.000
	Control	16	23.31	3.99			

4.4 Analysis of cognitive load

A one-way ANCOVA was conducted to assess the impact of cognitive intervention on post-test cognitive load, with pre-test cognitive load serving as a covariate. Assumptions for the analysis were initially scrutinized, ensuring their fulfillment. Levene’s test indicated homogeneity of variance, revealing consistent variances in post-test cognitive load scores between the experiment and control groups ($F = 10.2, p = .000$). Table 4 presents the ANCOVA results, demonstrating a significant difference in post-test cognitive load scores between the experiment and control groups ($F = 10.2, p = .000, \eta^2 = 0.41$). The homogeneity of regression coefficients further affirmed the reliability of ANCOVA outcomes, signifying a consistent covariate effect (pre-test cognitive load) across groups [8], [55]. The significant F-statistic highlights a meaningful disparity in post-test cognitive load, with an effect size (η^2) indicating that 41% of the variance is attributable to group membership. Implementing one-way ANCOVA, incorporating careful consideration of covariates, revealed a substantial difference in post-test cognitive load between the students engaging with mobile AI-powered ChatGPT and those in the control groups [8], [55].

Table 4. Univariate analysis results (cognitive load)

Test	Group	N	Mean	Std. Deviation	F	η^2	Sig
Cognitive load	Experiment	16	4.5	0.50	10.2	0.41	.000
	Control	16	3.2	1.0			

4.5 Analysis of perceived learning value

Table 5 reports the analysis results for perceived learning value scores. These scores were measured by using surveys before and after the study among participants in the experiment and control groups. The analysis indicates a big difference in perceived learning value scores between the two groups. People in the intervention group who used AI-based intervention recorded a relatively higher mean score for perceived learning value ($M = 4.7, SD = 0.36$) than the control group ($M = 2.8, SD = 0.74$). This is supported by the highly significant F-value of 41.5 ($p < .001$), indicating a substantial impact of the intervention on perceived learning value [55]. Moreover, the effect size ($\eta^2 = 0.74$) indicates a significant practical impact of the intervention, thus supporting the fact that there is a considerable influence on raising the participants’ perceptions of their learning value after the intervention. The results presented above indicate that the mobile AI-based intervention significantly influenced participants’ perceptions of the value of their learning experiences compared to those of the control group.

Table 5. Univariate analysis results (perceived learning value)

Test	Group	N	Mean	Std. Deviation	F	η^2	Sig
Perceived learning value	Experiment	16	4.7	0.36	41.5	0.74	.000
	Control	16	2.8	0.74			

4.6 Analysis of perceived trust

Table 6 presents the univariate analysis results for perceived trust scores among participants in the experiment and control groups. These scores were assessed using

pre- and post-surveys to gauge changes in perceived trust following the intervention. The findings reveal a significant difference in perceived trust scores between the experiment and control groups. Exposed to the AI-based intervention, participants in the experimental group exhibited a notably higher mean perceived trust score ($M = 4.6$, $SD = 0.46298$) than those in the control group ($M = 3.4$, $SD = 0.71149$). This difference is underscored by a statistically significant F-value of 17.6 ($p < .001$), indicating a substantial effect of the intervention on perceived trust levels [8], [55].

Furthermore, the effect size ($\eta^2 = 0.55$) suggests a large practical significance of the intervention, emphasizing its substantial impact on enhancing participants' perceived trust. These results indicate that the AI-based intervention significantly influenced perceived trust among participants, leading to higher levels of trust in the experimental group than in the control group. In a nutshell, the statistical significance and effect size of the observed differences in perceived trust scores highlight the effectiveness of the mobile AI-based intervention in positively impacting participants' trust perceptions. These findings provide valuable insights into the role of AI technologies, such as ChatGPT, in fostering trust and confidence in educational settings.

Table 6. Univariate analysis results (perceived trust)

Test	Group	N	Mean	Std. Deviation	F	η^2	Sig
Perceived Trust	Experiment	16	4.6	.46298	17.6	0.55	.000
	Control	16	3.4	.71149			

4.7 Analysis of learning motivation

Table 7 displays the univariate analysis results for learning motivation scores, measured using pre- and post-surveys, among participants in the experiment and control groups. The analysis reveals a significant difference in learning motivation scores between the two groups. Participants in the experimental group, exposed to the mobile AI-powered ChatGPT-based intervention, exhibited a substantially higher mean learning motivation score ($M = 4.7$, $SD = 0.36$) than those in the control group ($M = 2.8$, $SD = 0.74$). This difference is supported by a statistically significant F-value of 17.8 ($p < .001$), indicating a significant effect of the intervention on learning motivation levels [8], [55]. Moreover, the effect size ($\eta^2 = 0.552$) suggests a large practical significance of the intervention, emphasizing its considerable impact on enhancing participants' learning motivation. These results indicate that mobile AI-based intervention significantly influenced learning motivation among participants, leading to higher motivation levels in the experimental group than in the control group.

Table 7. Univariate analysis results (learning motivation)

Test	Group	N	Mean	Std. Deviation	F	η^2	Sig
Learning Motivation	Experiment	16	4.7	0.36	17.8	.552	.000
	Control	16	2.8	0.74			

These insights underscore the multifaceted impact of mobile AI-based chatbots on students' perceptions, aligning with the dimensions of facilitating engagement, fostering ubiquitous learning, and enhancing personalized factors that contribute to intrinsic motivation.

5 DISCUSSION

The integration of ChatGPT, an AI-based chatbot, in educational settings has gained significant attention due to its potential impact on students' academic experiences. This study explores the effects of mobile AI-powered ChatGPT on academic performance, cognitive load, perceived learning value, perceived trust, and learning motivation among university students. The comprehensive results obtained from achievement tests, cognitive load assessments, and self-reported measures of perceived learning value, perceived trust, and learning motivation provide valuable insights into the potential benefits and challenges associated with incorporating AI-driven technologies in higher education.

RQ1: How does the use of mobile AI-powered ChatGPT impact the pre-service students' academic performance after Post lesson?

In addressing RQ1, the study examines the impact of mobile AI-powered ChatGPT on pre-service students' academic performance following post-lesson activities. The findings indicate a significant enhancement in academic performance among students who utilized ChatGPT through mobile platforms. Specifically, the experimental group, which had access to ChatGPT via mobile devices during and after post-lesson sessions, demonstrated notably higher achievement test scores than the control group. This observation shows the beneficial influence of mobile AI-powered ChatGPT on students' academic outcomes [8], [56]. The results of this study are consistent with prior research emphasizing the positive effects of AI interventions, including ChatGPT, on academic performance [57]. Furthermore, the studies by Jaggars and Xu (2016) [58] and Lee et al. [8] have highlighted the efficacy of mobile-powered AI technologies in improving learning outcomes. This study suggests that when students receive support from AI-driven tools such as ChatGPT through mobile platforms, it contributes to their academic success by providing immediate access to information, facilitating personalized learning experiences, and offering continuous assistance [8], [58]. In addition, the notable academic performance improvement gained in the experimental group indicates that incorporating ChatGPT in post-lesson activities positively impacts students' learning experience. Using ChatGPT on mobile devices during review sessions, students probably gained from its ability to offer instant feedback, explain concepts, and provide extra learning materials. Therefore, the results of this study emphasized the potential of mobile AI-powered ChatGPT as an effective tool for improving pre-service students' academic performance and learning outcomes in schools.

RQ2: What is the cognitive load experienced by pre-service students when engaging with ChatGPT in a mobile learning environment?

In addressing RQ2, this study examines the cognitive load experienced by pre-service students while using ChatGPT within a mobile learning environment. The findings indicate that ChatGPT significantly reduces students' cognitive load, particularly in mobile-based learning settings where instant access to AI-powered support enhances learning efficiency. Specifically, the experimental group, which engaged with ChatGPT on mobile devices during their learning sessions, reported a lower cognitive load than the control group. This aligns with existing research highlighting the potential of AI-driven mobile chatbots to offload cognitive demands and streamline the learning process [57].

Prior studies by Bai et al. [59], Essel et al. [60], Kim et al. [61], Klos et al. [62], and Wu [63] support the role of mobile AI-powered tools in mitigating cognitive challenges and improving learning efficiency. ChatGPT provides immediate responses, personalized explanations, and supplementary learning materials in mobile learning environments, likely contributing to cognitive ease and reduced mental effort for students. Accessing ChatGPT on mobile devices anytime and anywhere enhances flexibility and responsiveness, further alleviating cognitive difficulties and supporting adaptive learning.

Moreover, the integration of ChatGPT into mobile learning signifies the modernization of educational practices, aligning with the increasing use of AI technologies in education. Mobile ChatGPT fosters an intuitive and adaptive learning experience by enabling real-time, AI-driven interactions, ultimately optimizing cognitive engagement. Overall, the results highlight the potential of AI-powered mobile chatbots as effective tools for reducing cognitive load and enhancing the learning process, reinforcing their value in improving student outcomes in mobile learning environments.

RQ3: How do students perceive the learning value derived from the experience of using ChatGPT in mobile learning environments?

In addressing RQ3, which explores students' perceptions of the learning value gained from using ChatGPT in a mobile learning environment, the study reveals a strong positive impact of mobile AI-powered ChatGPT on students' learning experiences. The qualitative findings indicate that ChatGPT, when accessed via mobile devices, enhances engagement, supports ubiquitous learning, and fosters personalized learning experiences that drive intrinsic motivation among students [64]. These results are consistent with existing literature, highlighting mobile AI-driven technologies' role in improving student engagement and motivation. Studies [11], [65]–[68] confirm that mobile AI chatbots, such as ChatGPT, contribute to active learning by offering personalized interactions, real-time responses, and seamless access to high-quality resources.

The integration of ChatGPT into mobile learning environments enhances the perceived learning value by providing students with instant feedback, contextualized support, and adaptive learning pathways tailored to their needs. Interacting with ChatGPT on mobile devices ensures learning continuity beyond traditional classroom settings, allowing students to access educational support anytime and anywhere. This aligns with the growing preference for flexible, self-directed learning models in digital education.

Moreover, the mobile accessibility and responsiveness of ChatGPT further intensify its influence on students' perceptions of learning value. By adapting to individual learning needs and preferences, ChatGPT in a mobile learning context fosters a more interactive and engaging educational experience, ultimately leading to greater student satisfaction and improved learning outcomes [8], [50], [67]–[69]. The findings confirm that mobile AI-powered ChatGPT significantly enhances students' learning experiences by making education more accessible, personalized, and interactive. These results emphasize the need to integrate AI technologies into mobile learning environments further to boost student motivation and optimize learning effectiveness.

RQ4: To what extent does students' perceived trust contribute to the effectiveness of Mobile AI-powered ChatGPT in facilitating learning review and feedback?

RQ4 examines students' perceived trust in mobile AI-powered ChatGPT and its role in facilitating learning review and feedback. The findings reveal that trust in ChatGPT significantly enhances its effectiveness in providing review and feedback

when accessed via mobile devices. The results indicate a higher level of perceived trust among students in the experimental group compared to the control group, suggesting that the seamless, on-the-go accessibility of ChatGPT via mobile devices contributes to its credibility and reliability as a learning tool.

This aligns with prior research emphasizing the importance of trust in AI-driven educational tools, particularly in mobile learning contexts. Studies have shown that students who perceive their mobile learning platforms as trustworthy exhibit higher engagement and motivation in their academic activities [65], [67], [70]. The ability to receive real-time, contextually relevant feedback through a mobile AI-powered chatbot reinforces students' confidence in the accuracy and dependability of ChatGPT's responses.

Moreover, the integration of ChatGPT into mobile learning environments fosters a sense of trust by offering instant, personalized, and adaptive feedback. The responsiveness of ChatGPT in a mobile setting allows students to review lessons, clarify doubts, and receive guidance anytime and anywhere, creating a more supportive and efficient learning experience. This trust in ChatGPT's capabilities directly improves student engagement, motivation, and learning outcomes.

Thus, perceived trust emerges as a critical factor in determining the effectiveness of mobile AI-powered ChatGPT in facilitating learning review and feedback. The findings underscore the importance of ensuring AI-driven educational tools maintain credibility, accuracy, and reliability, particularly in mobile learning environments, to enhance student confidence and maximize the benefits of AI-assisted learning.

RQ5: How does using Mobile AI-powered ChatGPT impact pre-service students' motivation to learn?

RQ5 explores the impact of mobile AI-powered ChatGPT on students' learning motivation. The findings indicate that ChatGPT's integration into a mobile learning environment significantly enhances student motivation, particularly in the experimental group, where students accessed ChatGPT via mobile devices for post-lesson support and feedback. The ability to receive instant, personalized, and mobile-responsive interactions emerged as a key factor in boosting motivation and engagement.

These results align with existing literature, which highlights AI-driven mobile learning tools as catalysts for increasing student motivation and engagement [8], [50], [67]–[69]. Dahri et al. [70] suggest that chatbots such as ChatGPT promote student-centered learning, increase autonomy, and enhance willingness to learn when integrated into mobile learning environments. Similarly, Moya et al. [71] argue that mobile AI-based chatbots empower students by providing real-time, context-aware feedback, enabling them to manage their learning progress more effectively.

The study findings further reveal that students using ChatGPT on mobile devices exhibited higher engagement, reduced cognitive load, and increased trust, ultimately leading to greater motivation and improved academic performance [50], [63], [73]. Mobile accessibility ensures students can learn anytime and anywhere, reinforcing the flexibility and convenience of AI-powered mobile learning tools.

Furthermore, ChatGPT's role in providing immediate mobile-based feedback fosters active learning, prompting deeper discussions and personalized interactions. This supports existing research emphasizing the significance of instant and mobile-friendly feedback in sustaining student motivation [8], [74], [75]. Integrating mobile AI-powered ChatGPT in education enhances engagement, trust, and motivation, creating a dynamic and interactive mobile learning experience.

These findings highlight ChatGPT's potential to promote positive learning attitudes among pre-service students within mobile learning environments. The study

reinforces the importance of leveraging mobile AI-powered technologies to foster personalized, accessible, and motivation-driven learning experiences.

5.1 Implications for mobile AI-powered ChatGPT in educational settings

Integrating mobile AI-powered ChatGPT in educational settings has significant implications for advancing mobile learning environments and enhancing student learning experiences. The positive outcomes observed across various dimensions suggest that AI-driven chatbots, accessible via mobile devices, can foster more engaging and effective learning environments. This holds broader relevance for educators, instructional designers, and policymakers aiming to optimize mobile-based educational practices.

The study highlights the potential of mobile AI-powered ChatGPT in managing cognitive load efficiently, offering insights into how mobile AI interventions can help students optimize their cognitive resources anytime, anywhere. Additionally, instant feedback, personalized interactions, and ubiquitous accessibility on mobile platforms emerge as key motivational factors, underscoring the importance of integrating AI chatbots as practical tools for fostering student motivation in mobile learning.

The findings further imply the need for pedagogical adaptations, encouraging educators to incorporate mobile AI-driven learning tools into instructional practices. This shift aligns with the evolving landscape of mobile education, where on-demand, personalized, and responsive learning experiences are increasingly valued. Moreover, the study suggests that AI-powered mobile solutions can enhance student support services, making learning more adaptive, inclusive, and accessible beyond traditional classroom settings. Beyond pre-service education, AI-powered mobile learning solutions can be effectively leveraged in diverse educational contexts, including professional development, lifelong learning, and corporate training. By integrating AI chatbots, institutions can offer learners of all backgrounds flexible and self-paced learning experiences, extending beyond conventional higher education settings.

Furthermore, the study's findings align with broader trends in digital education, particularly the increasing role of AI-driven learning environments. As AI becomes more sophisticated, its applications in personalized learning, adaptive tutoring, and formative assessment are expanding. This research reinforces that mobile AI-powered tools can complement traditional learning approaches by offering real-time academic support, bridging learning gaps, and facilitating continuous skill development in various disciplines.

As AI-based chatbots continue to shape education, continuous research and evaluation remain essential to understanding their long-term effects and addressing potential challenges in mobile learning environments. Ethical considerations and inclusivity should be prioritized in policy discussions, guiding stakeholders to develop responsible AI integration frameworks for educational use. Collaborations with industry partners specializing in AI technologies can further refine mobile-based educational tools, ensuring alignment with academic needs and industry advancements.

The study highlights the transformative potential of mobile AI-powered ChatGPT in education, urging stakeholders to thoughtfully and inclusively integrate these technologies to benefit diverse student populations. The mobile accessibility, interactive capabilities, and personalized support of AI-powered ChatGPT present a paradigm shift in digital learning, paving the way for a more student-centered, efficient, and engaging educational experience.

6 CONCLUSION

Integrating mobile AI-powered ChatGPT in education has gained substantial attention for its potential to transform mobile learning experiences. This study examines the effects of ChatGPT in a mobile learning environment, focusing on its impact on academic performance, cognitive load, perceived learning value, trust, and motivation among university students. As the educational landscape shifts towards mobile and AI-driven solutions, traditional teaching methods often struggle to meet the dynamic needs of today's learners. This study aims to explore how mobile AI-powered ChatGPT enhances student learning, providing an innovative and accessible approach to education. To achieve these objectives, we conducted a controlled study with an experimental and control group, using pre- and post-test statistical analysis to assess students' experiences. The findings reveal that mobile-based ChatGPT significantly improves academic performance, optimizes cognitive load management, enhances perceived learning value, fosters trust, and boosts motivation. Students who accessed ChatGPT via mobile platforms demonstrated higher test scores, reduced cognitive strain, stronger engagement, and greater confidence in AI-powered feedback and learning support. These results underscore the transformative role of AI-driven mobile learning tools in enhancing educational outcomes. The study's findings have broader implications for educators, policymakers, and technology developers, advocating for adopting mobile AI-powered tools to create engaging, responsive, and effective learning environments. Future implementations should emphasize inclusive design, ethical AI integration, and continuous research to refine and optimize their educational impact. This study serves as a foundation for further exploration into the role of AI-powered mobile learning, encouraging an adaptive, data-driven, and student-centered approach to harnessing the benefits of emerging technologies in education.

6.1 Limitations and future work

While this study highlights the positive impact of mobile AI-powered ChatGPT on academic performance, cognitive load management, and motivation, several limitations must be acknowledged. The small sample size ($n = 32$) limits the generalizability of the findings, necessitating future research with larger and more diverse participant groups to enhance the reliability of the results. Additionally, the sample was drawn from a specific educational context, which may limit the applicability of findings to broader learning environments. Future studies should examine how AI-driven mobile learning tools perform across educational settings, including vocational training, professional development, and informal learning spaces, to assess their scalability and effectiveness. Moreover, the limited duration of the intervention (two weeks) makes it challenging to assess long-term learning retention. Although students demonstrated immediate improvements in academic performance and engagement, future studies should explore whether these benefits persist over time through longitudinal assessments. Another notable limitation is the variability in students' prior exposure to AI-based learning tools, which may have influenced the outcomes. Some students were already familiar with AI-driven interactions, while others required additional time to adapt to the technology, potentially affecting their engagement levels and learning gains.

Despite the benefits of mobile AI-powered ChatGPT, the study also identified challenges in explaining complex questions. In such cases, students still required

teacher guidance to interpret difficult concepts and apply their knowledge to real-world scenarios. This suggests that AI chatbots should be integrated with human instructional support to create a balanced and effective learning experience. Future research should explore how AI-powered chatbots can be optimized for various learning contexts, including pre-lesson preparation, in-lesson support, and post-lesson review, to identify optimal usage patterns. Additionally, examining the impact of AI-driven personalized feedback mechanisms in mobile learning environments, particularly for large-scale implementations, could provide deeper insights into how AI can enhance individualized learning experiences. Another critical limitation is the potential bias in AI-generated responses. Since ChatGPT is trained on vast datasets, there is a risk of misinformation, outdated knowledge, or cultural bias, which could influence students' learning experiences. Future research should investigate strategies to mitigate AI biases in educational contexts by incorporating real-time content validation, educator oversight, and domain-specific training datasets to improve the reliability of AI-generated learning materials.

As AI technology evolves, future studies should also investigate the long-term effects of Mobile AI-powered ChatGPT on academic achievement and cognitive engagement across different educational levels, including primary, secondary, and higher education. Comparative studies across diverse learning environments could help determine the most effective AI-driven strategies for various age groups and subject areas. Moreover, integrating AI chatbots with human instructors into hybrid models could provide a more interactive and responsive learning experience, ensuring that students receive timely support where AI alone may be insufficient. To ensure equitable access and adoption, research should also explore AI-driven mobile learning interventions in underprivileged and resource-constrained educational settings, addressing potential disparities in digital literacy and technological infrastructure.

To further strengthen AI's role in education, collaborations with industry partners specializing in AI and educational technology should be encouraged to refine AI-driven interventions. Expanding the scope of AI-enhanced mobile learning to different disciplines with larger sample sizes and extended study durations will offer a more comprehensive understanding of its effectiveness and potential challenges. Future research should address these concerns while ensuring that AI-driven educational tools are inclusive, ethically designed, and aligned with best pedagogical practices to maximize their impact on student learning outcomes.

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8 REFERENCES

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