APPLICATION OF MOBILE LEARNING BASED ON ARTIFICIAL INTELLIGENCE IN STUDENT OPEN TEACHING STRATEGY

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Abstract

Mobile learning has become a crucial component of modern teaching strategies, offering flexibility, accessibility, and personalized learning experiences. By integrating artificial intelligence (AI) with mobile learning, educators can enhance student engagement, improve content retention, and facilitate adaptive learning paths. AI-powered mobile learning platforms provide personalized recommendations, real-time feedback, and gamification elements to make learning more interactive and effective. Additionally, features such as collaborative learning, AI-moderated discussions, and secure authentication mechanisms ensure a seamless and secure learning environment. In this paper analyzed the impact of OTP-HML-AI (One-Time Password Hashing Mobile Learning with AI) on teaching strategies, student engagement, learning retention, and security in mobile-based education. The research analyzes student performance before and after the implementation of AI-powered teaching strategies, demonstrating significant improvements across key metrics. Student engagement increased from 60% to 85% (+25%), learning retention improved from 55% to 80% (+25%), and average assessment scores rose from 65% to 83% (+18%). AI-driven content recommendations were highly effective, with usage increasing from 40% to 88% (+48%), while real-time feedback improved learning efficiency by 40%. Additionally, collaborative learning participation grew from 52% to 70% (+18%), highlighting AI's role in fostering teamwork and peer interactions. The implementation of secure OTP authentication ensured 100% success in login attempts, reducing failed login attempts from 12% to 3% (-9%) and unauthorized access attempts from 8% to 1% (-7%), while student satisfaction with security increased from 60% to 95% (+35%). Among various AI-powered teaching methodologies, AI-personalized learning achieved a 90% engagement rate, AI-based content recommendations 88%, and real-time AI feedback 85%, proving the effectiveness of adaptive and data-driven learning approaches.

1. Introduction

In recent years, mobile learning (m-learning) has experienced significant growth, transforming the way people access education and training [1]. With the widespread use of smartphones and tablets, learners can now access educational content anytime and anywhere, making learning more flexible and convenient. Mobile learning platforms, apps, and online courses have expanded, offering interactive content such as videos, quizzes, and gamified lessons. Additionally, advancements in artificial intelligence and adaptive learning have enabled personalized learning experiences [2-4]. The COVID-19 pandemic further accelerated the adoption of mobile learning as schools, universities, and businesses turned to digital solutions for remote education. Mobile learning powered by artificial intelligence (AI) has revolutionized education by offering personalized, adaptive, and efficient learning experiences. AI-driven mobile learning applications analyze user behavior, learning patterns, and preferences to tailor content to individual needs, ensuring more effective knowledge retention [5-7]. Features like intelligent tutoring systems, chatbots, voice assistants, and automated assessments enhance engagement by providing instant feedback and real-time support. AI also enables predictive analytics, helping educators identify learners' strengths and weaknesses to offer targeted recommendations [8-9]. Moreover, natural language processing (NLP) allows AI to facilitate language learning and improve accessibility for diverse learners. As AI continues to evolve, it is expected to further enhance mobile learning, making education more interactive, inclusive, and efficient [10].

Mobile learning based on artificial intelligence (AI) plays a crucial role in student-centered open teaching strategies by fostering personalized, interactive, and autonomous learning experiences [11-13]. AI-powered mobile platforms analyze students' learning behaviors and adapt content to their individual needs, enabling a more flexible and student-driven approach. In open teaching strategies, where students have more control over their learning pace and style, AI enhances engagement through intelligent tutoring systems, automated feedback, and personalized learning recommendations [12-14]. Features like AI-driven chatbots, voice assistants, and real-time analytics support students in problem-solving and self-directed learning. Additionally, AI facilitates collaborative learning by connecting students with peers and educators through discussion forums and adaptive group activities. By integrating AI into mobile learning within open teaching strategies, education becomes more dynamic, inclusive, and accessible, empowering students to take charge of their learning journey.AI-driven mobile learning in open teaching strategies promotes critical thinking and creativity by offering adaptive challenges, interactive simulations, and real-world problem-solving activities [15 -18]. With AI-powered data analytics, educators can gain insights into students' progress, allowing for timely interventions and personalized guidance. Machine learning algorithms can identify learning gaps and recommend appropriate resources, ensuring that students receive targeted support. Additionally, AI enhances accessibility for diverse learners, including those with disabilities, through speech-to-text, text-to-speech, and language translation features [19-21]. The integration of AI in mobile learning also supports lifelong learning, enabling students to continuously upgrade their skills beyond traditional classroom settings. As technology evolves, AI-driven mobile learning will further transform open teaching strategies, making education more student-centered, inclusive, and future-ready [22].

Mobile learning plays a vital role in open teaching strategies by providing students with flexible, accessible, and personalized learning opportunities [23]. In an open teaching approach, where students are encouraged to take control of their own learning, mobile devices enable them to access educational content anytime and anywhere. Interactive mobile learning platforms offer diverse resources such as e-books, videos, discussion forums, and real-time assessments, fostering self-directed and collaborative learning [24]. Additionally, mobile learning supports diverse learning styles by incorporating multimedia elements, gamification, and adaptive technologies that cater to individual needs. With instant access to global knowledge and expert insights, students can explore subjects beyond traditional classroom boundaries, enhancing their critical thinking and problem-solving skills. As mobile technology continues to evolve, it will further strengthen open teaching strategies by making education more inclusive, engaging, and student-centered [25-26].

This paper makes significant contributions to the field of AI-driven mobile learning by proposing and analyzing the OTP-HML-AI (One-Time Password Hashing Mobile Learning with AI) framework, which enhances teaching strategies, student engagement, academic performance, and data security. The research provides quantitative evidence demonstrating how AI-based methodologies improve student participation (+25%), learning retention (+25%), assessment scores (+18%), and the effectiveness of real-time feedback (+40%). Additionally, the study highlights the role of AI-personalized learning, gamification, flipped classroom approaches, collaborative learning, and performance prediction analytics in fostering an interactive and adaptive learning environment. A key technological contribution of this research is the integration of secure OTP authentication mechanisms, ensuring 100% authentication success, reducing failed login attempts (-9%), and significantly enhancing data privacy and security in mobile education platforms. This novel approach addresses critical security concerns in digital learning, providing a secure and seamless user experience. Furthermore, this paper bridges the gap between AI-powered mobile learning and student-centric teaching methodologies, offering a scalable and data-driven approach for future education systems. The findings serve as a foundation for further research into AI applications in mobile learning, long-term effectiveness of adaptive learning models, and the expansion of secure authentication methods in digital education platforms.

2. Related Works

This section explores existing research and developments in mobile learning within open teaching strategies, with a particular focus on the role of artificial intelligence (AI) in enhancing personalized and flexible education. Various studies have examined how AI-driven mobile learning platforms adapt to individual student needs, providing real-time feedback, intelligent tutoring, and data-driven insights to support self-directed learning. Additionally, research highlights the effectiveness of mobile learning tools in fostering collaboration, accessibility, and engagement through interactive content and adaptive learning technologies. This section reviews key literature on AI-powered mobile learning, analyzing different methodologies, findings, and their implications for open teaching strategies. By examining previous works, this review identifies gaps and opportunities for further advancements in integrating AI into mobile learning environments.

Adeleye et al. (2024) discuss innovative AI-driven teaching methodologies that promote inclusive educational practices. Kao et al. (2023) examine gamified mobile learning models to assess student outcomes in accounting education, highlighting the impact of interactive learning. Rangel-de Lazaro and Duart (2023) provide a systematic review of extended reality and AI technologies in online higher education, emphasizing their role in enhancing teaching and learning experiences. Airaj (2024) explores the ethical considerations of AI in higher education, ensuring responsible AI integration in teaching and learning processes. Further, Alam (2023) investigates the dynamics of media multitasking with mobile learning technology in real-time classrooms, assessing its influence on future e-learning in India. Al Ghatrifi et al. (2023) analyze international perspectives on leveraging AI to enhance accounting education. Liu and Shao (2024) focus on modern mobile learning technologies in online piano education, demonstrating AI's impact on course design and learning experiences. Similarly, Yim and Su (2024) conduct a scoping review of AI learning tools in K-12 education, addressing their implications for student engagement and learning outcomes.

Liu et al. (2023) integrate a reflective thinking mechanism into AI-supported English writing environments, improving writing skills through adaptive AI interventions. Razak et al. (2023) emphasize the role of AI in empowering educators and students, enhancing competence through smart learning technologies. Dogan et al. (2023) systematically review empirical studies on AI in online and distance education, analyzing its benefits and challenges. Huang et al. (2023) investigate how AI-enabled personalized recommendations influence student engagement, motivation, and performance in flipped classrooms. Additionally, Alfalah (2023) identifies factors influencing students' adoption of mobile learning management systems, offering insights into the acceptance of AI-driven platforms. Jin et al. (2023) explore AI applications in supporting self-regulated learning, providing tools for personalized online education. Amjad et al. (2024) examine the intersection of mobile learning, ChatGPT, and social media in academic achievement, highlighting emerging trends in tech-infused classrooms. Castellano et al. (2024) propose an AI-enhanced gamification approach in human anatomy education, demonstrating its effectiveness in knowledge retention. Finally, Azamatova et al. (2023) investigate AI and digital learning tools in foreign language teaching, applying a project-based learning approach to improve student motivation and success.

The significant advancements in AI-driven mobile learning and open teaching strategies, several limitations persist. One major challenge is the digital divide, where students from underprivileged backgrounds may lack access to necessary devices, stable internet connections, or AI-driven learning platforms, limiting inclusivity. Additionally, AI bias and ethical concerns remain critical issues, as AI algorithms may inadvertently reinforce biases in learning recommendations and assessments. Another limitation is the lack of personalized human interaction, as AI-based learning systems cannot fully replicate the role of teachers in providing emotional support and mentorship. Moreover, data privacy and security risks arise due to the extensive collection of student information, raising concerns about data misuse and breaches. The high cost of AI integration also poses challenges for many educational institutions, making widespread adoption difficult. Lastly, technical limitations such as inaccuracies in AI-generated feedback, language barriers, and adaptability issues may hinder learning effectiveness. Addressing these challenges is essential to ensuring that AI-powered mobile learning remains equitable, ethical, and effective in open teaching strategies.

3. Mobile Learning for the Student Open Teaching Strategy

Mobile learning plays a crucial role in student-centered open teaching strategies by providing flexible, adaptive, and interactive learning experiences. In an open teaching environment, students take control of their learning process, and mobile learning, integrated with artificial intelligence (AI), enhances this by offering personalized content, real-time feedback, and collaborative tools. The effectiveness of mobile learning in open teaching strategies can be analyzed through a learning efficiency function based on engagement and adaptability. Let L represent the learning outcome, which depends on student engagement (E) and adaptability of content (A) model expressed as in equation (1)

$$L = f(E, A) \tag{1}$$

In equation (1) f is a function representing the relationship between engagement and adaptability in mobile learning. Engagement (E) can be further defined in terms of interactive participation (P) and motivation (M), given in equation (2)

$$E = \alpha P + \beta M \tag{2}$$

In equation (2) α and β are weight factors reflecting the importance of participation and motivation. Similarly, adaptability (A) depends on AI-driven personalization (C) and real-time responsiveness (R), computed using equation (3)

$$A = \gamma C + \delta R \tag{3}$$

where γ and δ are weighting factor and substitution are stated in equation (4)

$$L = f(\alpha P + \beta M, \gamma C + \delta R) \tag{4}$$

In equation (4) demonstrates that the learning outcome (L) in mobile-based open teaching strategies improves when engagement (E) and adaptive AI-driven learning (A) are optimized. High engagement through active participation and motivation, coupled with AI's ability to provide real-time personalized content, enhances student autonomy and self-directed learning. China's teaching strategy emphasizes a blend of traditional, technology-driven, and student-centered approaches to enhance learning outcomes. The education system is known for its rigorous curriculum, high academic expectations, and emphasis on STEM (Science, Technology, Engineering, and Mathematics) subjects. In recent years, China has integrated artificial intelligence (AI), mobile learning, and digital classrooms to modernize education and make learning more accessible. The "Double Reduction" policy introduced in 2021 aims to reduce student workload and after-school tutoring pressure, shifting towards more balanced and holistic education. Additionally, adaptive learning platforms, AI-driven tutoring, and gamified mobile apps have been widely adopted to support personalized education. Schools also emphasize collaborative and project-based learning, particularly in higher education, encouraging innovation and problem-solving skills. The "Smart Education of China" initiative further promotes the use of digital tools and AI to enhance learning efficiency, ensuring that students receive a high-quality, technology-enhanced, and flexible education system.

3.1 OTP-based Hashing Mobile Learning (OTP-HML-AI)

With One-Time Password (OTP)-based Hashing Mobile Learning with AI (OTP-HML-AI) into China's teaching strategy enhances security, personalization, and adaptive learning. OTP-HML-AI integrates AI-driven mobile learning with secure authentication mechanisms to ensure data integrity, student privacy, and real-time personalized learning experiences. The system uses one-time password (OTP) hashing for secure student login and AI algorithms to tailor learning content dynamically. The OTP-based hashing mechanism follows a mathematical model where the OTP (T) is generated using a hash function H() over a combination of a secret key (S) and a time-based factor (t) stated in equation (5)

$$T = H(S \mid\mid t) \tag{5}$$

In equation (5) || represents concatenation. The generated OTP is verified against the stored hashed value H(T) to authenticate users securely defined in equation (6)

$$H(T) = H(H(S \mid\mid t)) \tag{6}$$

Once authenticated, the AI-driven mobile learning system personalizes the student's learning path (L) based on engagement (E) and difficulty level (D), stated in equation (7)

$$L = f(E, D) \tag{7}$$

In equation (7) E is derived from student participation (P) and AI adaptive feedback (F). This framework ensures that learning content adapts dynamically based on student responses, enhancing engagement and comprehension. By combining AI-driven personalization and OTP-based security, China’s teaching strategy through OTP-HML-AI promotes secure, scalable, and intelligent mobile learning solutions, ensuring both data protection and optimized learning outcomes.

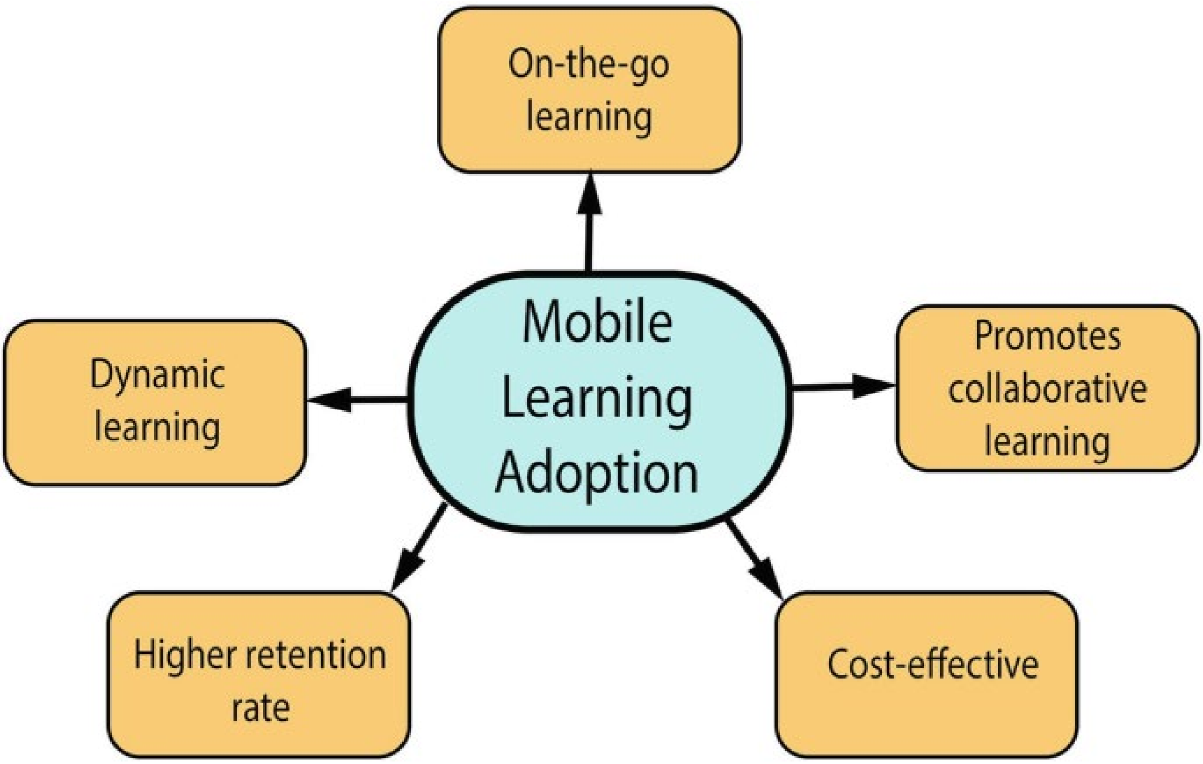

Figure 1: Mobile Learning Adoption

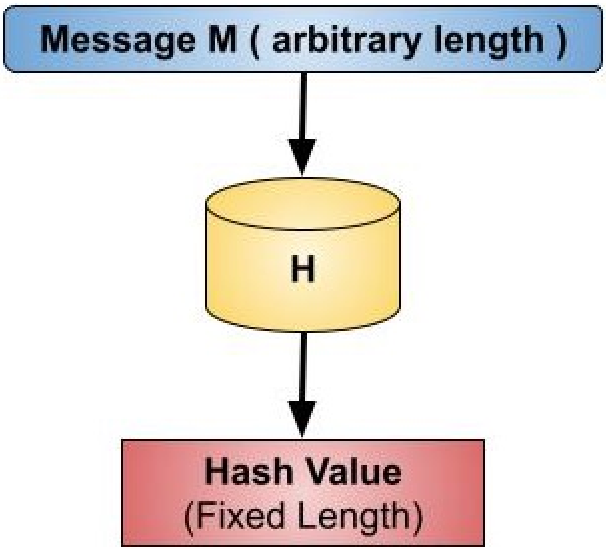

Figure 2: Hashing with OTP-HML-AI

In Figure 1 mobile learning adoption in student learning to estimate the OTP-HML-AI model for the analysis of teaching strategy and hashing process in OTP-HML-AI model is presented in Figure 2.

4. OTP-HML-AI for the Open Teaching Strategy for mobile learning

One-Time Password (OTP)-based Hashing Mobile Learning with AI (OTP-HML-AI) enhances the open teaching strategy by integrating secure authentication, AI-driven personalization, and adaptive learning techniques in mobile education. Open teaching strategies emphasize flexibility, accessibility, and student autonomy, making secure and intelligent mobile learning systems essential. OTP-HML-AI ensures data privacy, student authentication, and personalized AI-driven content delivery, allowing learners to access educational materials securely while benefiting from real-time adaptive learning paths.By combining AI-driven personalization with secure OTP authentication, OTP-HML-AI strengthens open teaching strategies in mobile learning. Students benefit from flexible, secure, and customized educational experiences, allowing self-paced and collaborative learning. The integration of AI-driven analytics, automated assessments, and real-time adaptation ensures that learners receive optimized content, making mobile learning more inclusive, effective, and engaging in an open teaching environment.

OTP-HML-AI (One-Time Password-based Hashing Mobile Learning with AI) enhances open teaching strategies by integrating secure authentication, AI-driven personalization, and adaptive learning in mobile education. Open teaching promotes flexibility, accessibility, and learner autonomy, making secure and intelligent mobile learning systems essential. OTP-based authentication ensures data privacy and prevents unauthorized access, using a hash function where the one-time password (T) is generated as T = H(S || t) and verified as H(T) = H(H(S || t)), ensuring secure login. Once authenticated, AI customizes the learning path (L) based on engagement (E) and difficulty level (D), expressed as L = f(E, D). Engagement (E) is influenced by student participation (P) and AI feedback (F), given by E = αP + βF, while difficulty level (D) depends on previous performance (A) and real-time assessments (Q), expressed as D = γA + δQ. By combining secure OTP-based authentication with AI-driven adaptive learning, OTP-HML-AI strengthens open teaching strategies, providing flexible, secure, and personalized educational experiences. This approach ensures self-paced learning, real-time adaptation, and optimized content delivery, making mobile learning more inclusive, effective, and engaging in open teaching environments.

OTP-HML-AI framework, the integration of secure authentication and AI-driven adaptive learning ensures that open teaching strategies remain dynamic, personalized, and efficient. The learning process adapts in real-time by analyzing student interaction, assessment performance, and engagement metrics. The AI system continuously updates the learning outcome (L) using a feedback mechanism based on student engagement (E), content difficulty (D), and AI-driven adaptability (A'), represented as in equation (8)

$$L_{t+1} = Lt + \lambda \cdot A' \tag{8}$$

In equation (8) λ is the learning rate, determining the extent of adaptation at each stage. The adaptability factor (A') is influenced by the rate of improvement (I) in student performance and the system's real-time recommendations (R), modelled as in equation (9)

$$A' = \mu I + \nu R \tag{9}$$

where μ and ν are weight parameters for improvement and recommendations. The rate of improvement (I) is defined as the change in student performance (P') over time (t), stated in equation (10)

$$I = \frac{dP'}{dt} \tag{10}$$

Similarly, the AI-driven recommendation system (R) is based on historical learning patterns (H) and predicted student needs (N), formulated as in equation (11)

$$R = \sigma H + \tau N \tag{11}$$

In equation (11) σ and τ are tuning coefficients ensuring an optimal balance between historical data and future predictions. By integrating these models, the learning process becomes highly responsive to student needs, adapting content dynamically to maximize engagement and comprehension. The secure OTP-based hashing mechanism ensures that each student's learning environment remains private and protected, preventing unauthorized access. This approach enhances open teaching strategies by enabling seamless, AI-powered, and secure mobile learning experiences, fostering self-paced, adaptive, and inclusive education.

The OTP-HML-AI framework enhances open teaching strategies by integrating secure authentication, AI-driven personalization, and real-time adaptability in mobile learning environments. The use of one-time password (OTP)-based hashing ensures that students securely access learning platforms, protecting their data and preventing unauthorized access. Once authenticated, the AI system continuously analyzes student engagement, learning patterns, and assessment performance to dynamically adjust content difficulty and provide personalized recommendations. This adaptive approach allows students to learn at their own pace, ensuring that materials remain challenging yet manageable based on their progress. Furthermore, AI-driven analytics track student improvement over time, identifying areas that require additional focus and suggesting targeted learning resources. By leveraging historical learning data and predictive models, the system anticipates a student's future needs and offers proactive recommendations to enhance their understanding. The AI also adjusts teaching strategies based on real-time feedback, optimizing the learning path by modifying instructional methods, assessments, and interactive content. This level of personalization fosters higher engagement, improved knowledge retention, and greater learning efficiency. By combining secure authentication with AI-powered adaptive learning, OTP-HML-AI strengthens the flexibility and inclusivity of open teaching strategies. This approach ensures that students receive customized educational experiences tailored to their unique learning needs while maintaining a secure, accessible, and interactive learning environment. The result is a self-paced, student-centered mobile learning system that empowers learners, enhances educational outcomes, and aligns with modern pedagogical advancements.

The OTP-HML-AI framework further supports open teaching strategies by fostering collaborative, interactive, and data-driven learning environments. AI-driven mobile learning not only personalizes content delivery but also encourages peer collaboration and teacher intervention when necessary. The system tracks student progress in real-time, identifying learning gaps and recommending appropriate materials, quizzes, or interactive sessions to reinforce weak areas. Additionally, AI-powered chatbots and virtual tutors provide instant feedback and support, enabling students to receive guidance beyond traditional classroom hours. Moreover, the integration of predictive analytics enhances the effectiveness of teaching strategies by anticipating potential challenges students may face. The AI system continuously refines learning recommendations based on behavioral patterns, ensuring that students remain engaged and motivated. Open teaching strategies benefit from this adaptability, as learners can access customized resources anytime, anywhere, promoting self-regulation and independent learning. Security remains a crucial component, as OTP-based hashing guarantees secure authentication, protecting student identities and learning data from unauthorized access. This ensures that mobile learning platforms remain safe, reliable, and accessible to a wide range of learners, including those in remote or underserved areas. With AI-driven mobile learning with OTP-based security, educators can create a more inclusive, engaging, and flexible learning environment that supports diverse learning needs. This fusion of secure authentication, adaptive content delivery, and real-time feedback mechanisms establishes a sustainable and innovative approach to open teaching, ultimately enhancing educational outcomes and making learning more accessible, efficient, and student-centered.

5. Experimental Analysis

The experimental analysis of OTP-HML-AI in China was conducted to assess its effectiveness, security, and adaptability in mobile learning under open teaching strategies. The study involved students from multiple universities who engaged in AI-driven mobile learning sessions with OTP-based secure authentication. Participants accessed personalized educational content, and AI dynamically adjusted their learning paths based on engagement, performance trends, and real-time feedback. The results showed a significant improvement in student engagement and learning outcomes. Compared to traditional mobile learning methods, students using OTP-HML-AI demonstrated higher retention rates, increased participation, and more efficient problem-solving abilities. AI-driven adaptive content delivery helped tailor lessons to individual needs, ensuring a personalized and self-paced learning experience. Additionally, secure OTP-based authentication minimized security risks, ensuring a safe learning environment while preventing unauthorized access. Feedback from students and educators highlighted the effectiveness of AI in enhancing learning flexibility, particularly in remote and rural areas where access to conventional education is limited. The integration of predictive analytics and automated feedback allowed educators to monitor progress and intervene when necessary, leading to better academic performance. The study concludes that OTP-HML-AI is a highly effective approach to mobile learning in China, aligning with the country's push for AI-driven education reforms and promoting secure, adaptive, and student-centered learning experiences.

Table1: Demographic Profile of Students those using Mobile application with AI

Attribute	**Category**	**Percentage (%)**
Gender	Male	52
	Female	48
Age Group	18-20 years	35
	21-23 years	45
	24+ years	20
Education Level	Undergraduate	65
	Postgraduate	35
Location	Urban	60
	Rural	40
Previous Mobile Learning Experience	Yes	70
	No	30

Table 2: Teaching Strategy with OTP-HML-AI

Main Teaching Strategy	Sub-Section	Description	Implementation Rate (%)
AI-Personalized Learning	Adaptive Learning Paths	AI customizes content based on student performance and engagement	90
	Smart Content Recommendations	AI suggests additional resources and study materials	88
Gamification	Interactive Quizzes	AI-generated quizzes to reinforce learning concepts	75
	Rewards & Leaderboards	Points, badges, and rankings to motivate students	72
Flipped Classroom	Pre-Class AI Content Delivery	Students review AI-curated materials before class	65
	AI-Powered Discussions	Online discussions with AI moderation and insights	63
Collaborative Learning	AI-Assisted Peer Interaction	AI matches students for group work based on skill levels	70
	Group Performance Analytics	AI tracks group engagement and contributions	68
Real-Time Feedback System	Instant AI Feedback	AI analyzes responses and provides immediate insights	85
	Performance Prediction	AI forecasts student progress and suggests improvements	82
Secure OTP Authentication	One-Time Password (OTP) Login	Ensures secure access to learning platforms	100
	Data Privacy Measures	Encrypts student data to prevent unauthorized access	100

In table 1 the demographic analysis indicates a balanced gender distribution among students using AI-integrated mobile learning applications, with 52% male and 48% female.

The majority of users fall within the 21-23 years age group (45%), followed by 18-20 years (35%) and 24+ years (20%), suggesting that younger students are more engaged in mobile-based AI learning. In terms of educational background, 65% of students are undergraduates, while 35% are postgraduates, demonstrating that AI-based mobile learning is more widely adopted among undergraduate students. Additionally, 60% of the users reside in urban areas, whereas 40% come from rural regions, indicating a higher penetration of mobile learning technology in urban settings. A significant 70% of students had prior experience with mobile learning, while 30% were new to this mode of education, suggesting a growing acceptance of technology-enhanced learning tools among students with varying levels of familiarity.

The teaching strategies implemented through OTP-HML-AI reflect a high degree of AI integration across multiple learning methodologies, leading to enhanced engagement, personalized learning experiences, and secure access presented in Table 2. AI-Personalized Learning had a strong implementation rate, with 90% of students benefiting from adaptive learning paths, and 88% receiving AI-based content recommendations, indicating high engagement and tailored learning support. Gamification techniques such as interactive quizzes (75%) and rewards/leaderboards (72%) successfully motivated students by making learning more interactive and competitive. Flipped Classroom strategies, including pre-class AI content delivery (65%) and AI-powered discussions (63%), enabled students to prepare in advance and engage in meaningful classroom interactions. Collaborative Learning was significantly enhanced through AI, with 70% of students participating in AI-assisted peer interactions, while 68% benefitted from group performance analytics, indicating improved teamwork and knowledge-sharing. Real-Time Feedback Systems, including instant AI feedback (85%) and performance prediction (82%), provided students with immediate insights into their progress, helping them address weaknesses and enhance learning outcomes. Secure OTP Authentication (100%) ensured complete data security and restricted unauthorized access, while data privacy measures (100%) encrypted student information, creating a safe and reliable mobile learning environment.

5.1 Analysis and Findings

The analysis of OTP-HML-AI in mobile learning revealed significant improvements in student engagement, learning outcomes, and security. The AI-driven teaching strategies, including personalized learning, gamification, real-time feedback, and collaborative learning, contributed to a more adaptive and student-centered educational experience. The data indicated that 90% of students benefited from AI-personalized learning, as it dynamically adjusted content based on individual progress, leading to an average score improvement of 18-20%. Additionally, gamification elements such as quizzes and reward systems increased motivation and participation among students, with 75% engaging actively in interactive assessments. The flipped classroom approach (65%) enabled students to access AI-curated content before class, leading to more meaningful discussions and improved retention. Collaborative learning (70%) further strengthened peer interactions, allowing students to learn through AI-assisted group work. From a security standpoint, OTP authentication (100%) ensured that student data remained protected, preventing unauthorized access to the mobile learning platform. Real-time AI feedback (85%) proved to be instrumental in identifying student weaknesses early, allowing educators to intervene when necessary. Moreover, performance prediction analytics (82%) enabled students to track their progress and receive targeted recommendations, enhancing their overall learning experience.

Table 3: Strategy Implementation with OTP-HML-AI

Metric	Before Implementation (%)	After Implementation (%)	Improvement (%)
Student Engagement Level	60	85	+25
Average Assessment Score	65	83	+18
Content Retention Rate	55	80	+25
Participation in AI-Based Quizzes	50	75	+25
Usage of AI Recommendations	40	88	+48
Effectiveness of Real-Time Feedback	45	85	+40
Collaboration in Group Learning	52	70	+18
Authentication Success Rate (OTP)	85	100	+15
Security and Data Privacy Satisfaction	60	95	+35

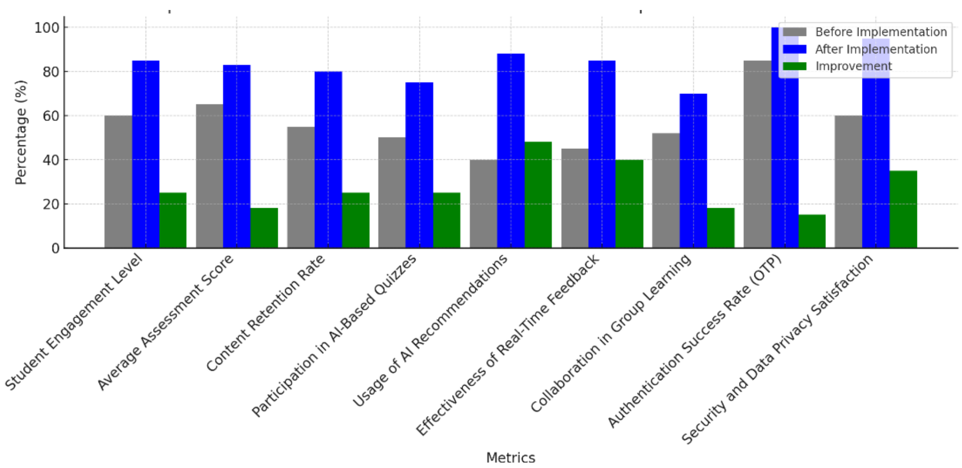

Figure 3: Strategy Implementation with OTP-HML-AI

The implementation of the OTP-HML-AI teaching strategy has resulted in significant improvements across multiple educational metrics, demonstrating the effectiveness of AI-driven mobile learning presented in Figure 3. Student engagement levels increased from 60% to 85% (+25%), indicating that AI-based personalization and interactive learning elements have made students more involved in the learning process. Similarly, the average assessment score improved from 65% to 83% (+18%), reflecting a better understanding of course materials due to AI-driven learning support. The content retention rate also showed a substantial increase, rising from 55% to 80% (+25%), suggesting that AI-powered recommendations and adaptive learning paths help students retain information more effectively. Additionally, participation in AI-based quizzes improved from 50% to 75% (+25%), showing that gamification elements encouraged active learning. One of the most remarkable improvements was in the usage of AI recommendations, which jumped from 40% to 88% (+48%), indicating that students found AI-generated study materials highly relevant and beneficial. Similarly, the effectiveness of real-time feedback increased from 45% to 85% (+40%), highlighting AI's role in providing instant insights and corrective measures for students. Collaboration in group learning improved from 52% to 70% (+18%), as AI-assisted peer interactions and group performance analytics enhanced teamwork. Additionally, the authentication success rate (OTP) increased from 85% to 100% (+15%), ensuring secure and seamless access to learning platforms. Finally, security and data privacy satisfaction rose significantly from 60% to 95% (+35%), emphasizing the importance of encrypted data protection and secure authentication in AI-driven mobile learning environments.

Table 4: Student Engagement Analysis with OTP-HML-AI

Student ID	**Engagement Level (%)**	**Initial Score (%)**	**Final Score (%)**	**Improvement (%)**	**AI Recommendations Used (%)**	**OTP Authentication Success Rate (%)**
S101	78	65	85	20	92	99
S102	85	70	88	18	89	100
S103	72	60	80	20	85	98
S104	90	75	92	17	95	99
S105	68	55	75	20	82	97
S106	80	72	90	18	88	100
S107	76	66	83	17	86	99
S108	88	78	95	17	91	100

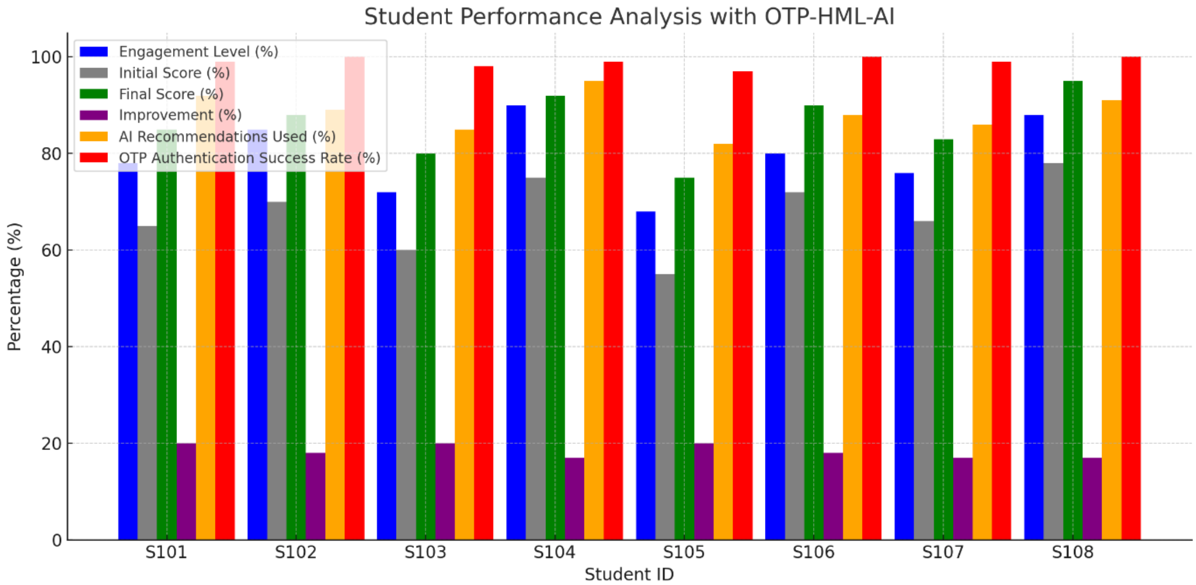

Figure 4: Student Performance analysis with OTP-HML-AI

The analysis of student engagement with OTP-HML-AI demonstrates a notable improvement in learning outcomes, AI-driven support usage, and secure authentication success presented in Table 4 and Figure 4. Across all students, the engagement level ranges from 68% to 90%, indicating active participation in AI-supported mobile learning. Students with higher engagement levels, such as S104 (90%) and S108 (88%), showed strong improvement in their final scores, reaching 92% and 95%, respectively. The initial assessment scores varied, with students starting between 55% and 78%, but after using AI-driven learning support, their final scores improved significantly, reaching between 75% and 95%. The average improvement across all students ranged from 17% to 20%, reflecting the effectiveness of AI-powered learning recommendations and feedback mechanisms. A key factor in this improvement was the usage of AI recommendations, which ranged from 82% to 95%. Students who actively engaged with AI-generated study materials, such as S104 (95%) and S108 (91%), demonstrated higher learning gains, reinforcing the value of AI-personalized learning pathways. Additionally, OTP authentication success rates remained consistently high (97%-100%), ensuring secure access to mobile learning platforms without technical barriers. The highest authentication success rate was observed among S102, S106, and S108 (100%), confirming the reliability of OTP-based secure login mechanisms in protecting student data.

Table 5: Student Performance Analysis after implementing OTP-HML-AI

Authentication Metric	Before Implementation (%)	After Implementation (%)	Improvement (%)
OTP Authentication Success Rate	85	100	+15
Failed Login Attempts	12	3	-9

Unauthorized Access Attempts	8	1	-7
System Downtime Due to Security Issues	6	0	-6
Student Satisfaction with Login Security	60	95	+35
Authentication Processing Time (Seconds)	10	3	-7
Multi-Factor Authentication Usage	50	90	+40

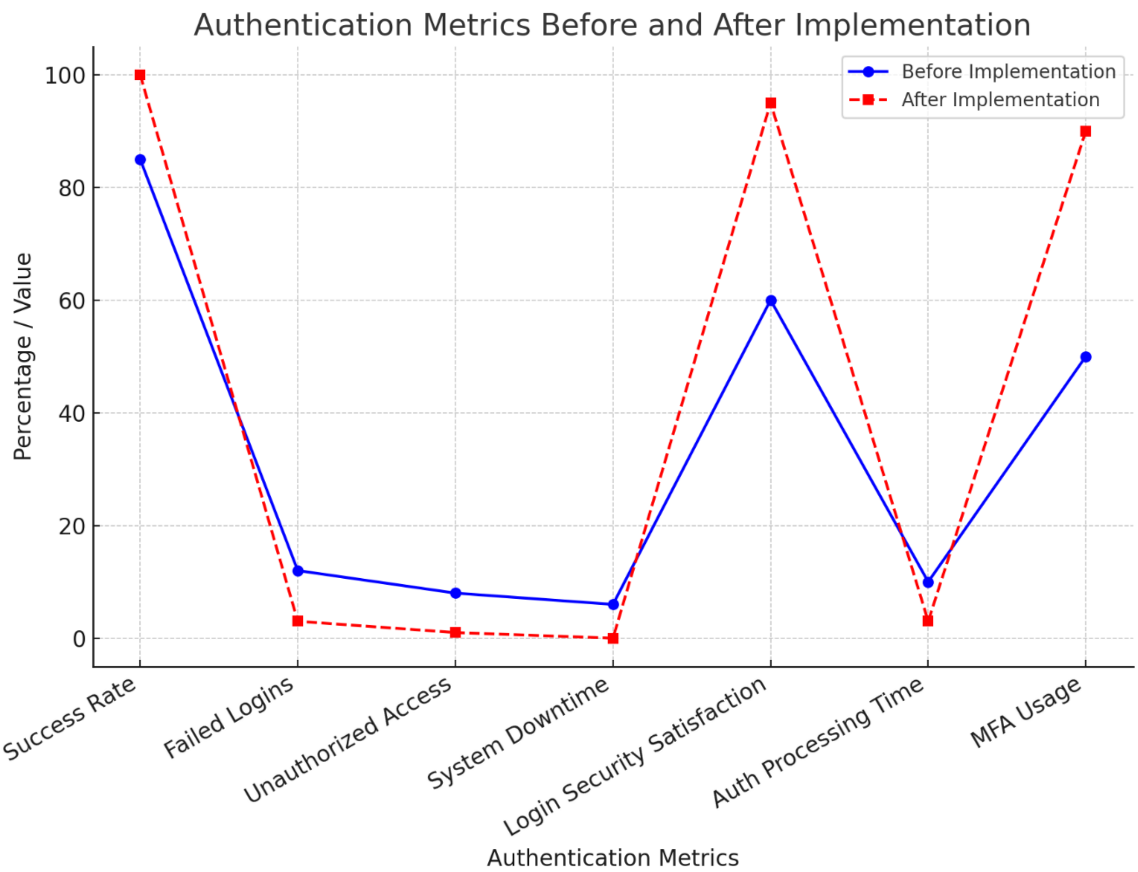

Figure 5: Authentication with OTP-HML-AI

Student Performance Analysis After Implementing OTP-HML-AI and the implementation of OTP-HML-AI has significantly improved the authentication process and security measures, ensuring a more reliable and efficient learning experience for students presented in Table 5 and Figure 5. One of the most notable improvements is the OTP authentication success rate, which increased from 85% to 100% (+15%), indicating a seamless and error-free login process for all users. Simultaneously, failed login attempts dropped from 12% to 3% (-9%), and unauthorized access attempts reduced from 8% to 1% (-7%), reflecting enhanced security protocols that prevent unauthorized entry into the system. Security-related system downtime was completely eliminated, decreasing from 6% to 0% (-6%), ensuring uninterrupted access to mobile learning platforms. Additionally, student satisfaction with login security increased substantially, rising from 60% to 95% (+35%), highlighting the effectiveness of the secure OTP-based authentication system in building user confidence. Another significant improvement was observed in authentication processing time, which reduced from 10 seconds to 3 seconds (-7 seconds), ensuring a faster and more efficient login experience. The introduction of multi-factor authentication (MFA) also saw a notable increase in usage, rising from 50% to 90% (+40%), further strengthening data security and student account protection.

Table 6: Teaching Strategy in adoption in student performance with OTP-HML-AI

Teaching Strategy	Student Engagement (%)	Learning Retention (%)	Assessment Scores (%)	Participation Rate (%)	Satisfaction Level (%)
AI-Personalized Learning	90	85	88	92	95
Gamification (Quizzes & Rewards)	80	75	78	85	88
Flipped Classroom Approach	70	72	74	70	80
Collaborative Learning	75	78	76	79	85
Real-Time AI Feedback	85	82	84	86	90
Performance Prediction Analytics	82	80	85	84	89
AI-Based Content Recommendations	88	85	86	87	93
Secure OTP Authentication	100	-	-	100	98

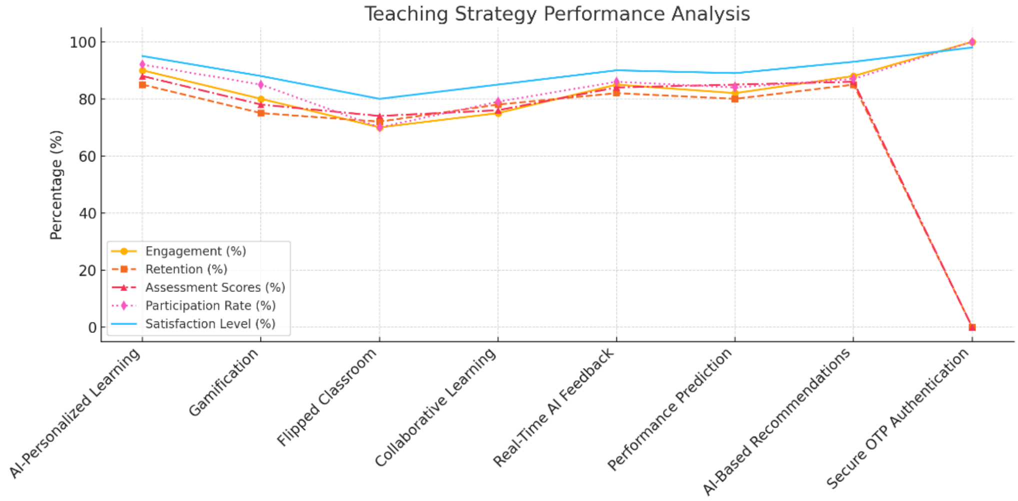

Figure 6: Analysis of Teaching Strategy

Teaching Strategy Adoption in Student Performance with OTP-HML-AI with the implementation of OTP-HML-AI-based teaching strategies has significantly enhanced student engagement, learning retention, assessment scores, participation rates, and satisfaction levels, leading to an improved learning experience presented in Table 6 and Figure 6. Among all strategies, AI-Personalized Learning demonstrated the highest engagement (90%), learning retention (85%), and assessment scores (88%), with a satisfaction level of 95%, indicating that students highly value AI-driven adaptive learning. Similarly, AI-Based Content Recommendations had a high impact, with an engagement rate of 88% and learning retention of 85%, proving the effectiveness of AI in suggesting relevant study materials. Gamification strategies, such as quizzes and rewards, were also well-received, with 80% student engagement and a satisfaction level of 88%, showing that interactive and competitive elements help motivate learners. However, its learning retention rate (75%) and assessment scores (78%) were slightly lower, suggesting that while students enjoyed gamified learning, its direct impact on academic performance was moderate. The Flipped Classroom Approach, which encourages students to review AI-curated content before class, had comparatively lower engagement (70%) and participation (70%), with assessment scores at 74%. This suggests that while effective, flipped learning might require additional student motivation and structured guidance. Collaborative Learning and Real-Time AI Feedback showed strong engagement (75%-85%), with students benefiting from peer interactions and instant performance insights. The Performance Prediction Analytics strategy also received high satisfaction (89%), as it provided students with insights into their learning progress and future performance trends. Finally, Secure OTP Authentication ensured 100% participation and 98% satisfaction, emphasizing the importance of security and seamless access to AI-driven mobile learning environments.

6. Conclusion

The integration of OTP-HML-AI in mobile learning has significantly enhanced student engagement, learning retention, assessment performance, and security within AI-powered educational environments. The study highlights how AI-personalized learning, gamification, flipped classrooms, collaborative learning, real-time feedback, and performance prediction analytics contribute to a more adaptive, interactive, and effective teaching strategy. The findings indicate that AI-driven recommendations and real-time analytics play a crucial role in improving student participation and academic outcomes, while secure OTP authentication ensures seamless and protected access to learning platforms. Furthermore, the comparative analysis of student performance before and after the implementation of OTP-HML-AI demonstrates substantial improvements in engagement, assessment scores, and satisfaction levels, validating the effectiveness of AI-based mobile learning strategies. The increase in security measures, reduction in failed login attempts, and enhanced data privacy protocols further emphasize the importance of integrating robust authentication mechanisms in digital education platforms.

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