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A Systematic Review of AI-Based Mobile Learning Environments: Unveiling Trends and Future Directions

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The diversity of mobile devices and the increasing availability of technology solutions support the growth and popularity of mobile learning environments. The ubiquitous nature of mobile devices has revolutionized learning, fostering the rise of mobile learning (m-learning). In combination with AI applications, m- learning environments further increase the potential for providing individualized solutions. This literature review delves into the current landscape of AI-based m-learning research. The findings are expected to unveil the immense potential of AI in transforming m-learning. Artificial intelligence's capabilities to personalize the learning experience, optimize the assessment process, and automate content adaptation and creation provide the opportunity to make m-learning more engaging and interactive with the potential offered by learning anytime, anywhere. The aim of this systematic review is to assess the current situation regarding the coordinated use of mobile learning and artificial intelligence applications. Recent studies in the last five years (2019-2023) were analyzed in Web of Science and Scopus databases. The systematic review was conducted in accordance with the PRISMA guidelines, and the relevant studies were analyzed with MAXQDA 24. The results include trends in research on applications used, personalized learning experience, independent learning, performance assessment and feedback, interaction, theoretical frameworks. Suggestions for future research are discussed based on the research results.

Introduction

The Symbiotic Relationship: AI and Mobile Learning

The integration of Artificial Intelligence (AI) into mobile learning environments (MLEs) has ushered in a transformative era, paving the way for a myriad of research avenues. Recent explorations in AI-powered mobile learning illuminate several key areas of focus, showcasing the dynamic nature of this burgeoning field.

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The exponential growth of mobile and digital technologies in recent years has catalyzed research in mobile learning (m-learning) and spurred interest in the advancement of mobile technologies (Md Osman & Md Napeah, 2021; Qureshi et al., 2020). The inherent mobility provided by ubiquitous access to information anytime, anywhere has expanded the boundaries of learning, with ubiquitous learning emerging as a focal point in m-learning research (Nordin et al., 2017; Pandey & Singh, 2015). Initiatives such as Bring Your Own Device (BYOD) capitalize on the flexibility and ubiquity of mobile devices in educational settings. Through these devices, m-learning facilitates the delivery of educational content in easily digestible, bite-sized units through micro-learning approaches (Kostas et al., 2024), all conveniently accessible on personal mobile devices. Moreover, it enhances the learning experience through the integration of augmented reality (AR) applications (Cai & Chen, 2018; Ekren & Keskin, 2017; Li, 2014; Sural, 2018), mobile apps, and gamification elements (Asadullah et al., 2023; Demirbilek, 2023; Sagirani et al., 2018), seamlessly merging digital information with the physical world.

Comprehensive bibliometric analyses reveal a significant increase in m-learning research, particularly after 2021 (Irwanto et al., 2023). Another study examining mobile learning research highlights a surge in intelligent tutoring system research between 2011 and 2015 (Goksu, 2021), indicating a growing interest in systems that monitor and assess students' learning processes, provide tailored feedback, and deliver learning materials to enhance individual learning experiences, hinting at an intersection with AI.

The advancement of AI technologies has brought about significant improvements across various domains such as healthcare, customer experience, and cross-industry operations (Dayal et al., 2023). Research into AI's application in education has also seen substantial growth in recent decades(Mupaikwa, 2023; Verma et al., 2021) and sought to solve the topic of how to employ AI in education. Zuboff (2020) conceptually summarized AI's four key roles in the learning and teaching process as profiling and prediction, intelligent tutoring systems, assessment and evaluation, and adaptive systems and personalization (Akinwalere & Ivanov, 2022; Zuboff, 2020). AI technologies enable personalized learning experiences, making learning environments more inclusive through adaptive learning. They facilitate the development of learning-teaching methodologies for both students and teachers, enhancing teaching efficiency by aiding in student performance prediction, measurement, evaluation, and development (Abdulmunem, 2023; Dayal et al., 2023; Mupaikwa, 2023). The impact of AI on the learning experience, along with its contributions to personalization, intersects with the growing interest in m-learning research. Intelligent tutoring systems, ubiquitous learning, artificial neural networks, cloud computing, and the utilization of machine learning and other AI algorithms have become focal points of AI-assisted m- learning research (Hwang et al., 2021), underscoring the significance of AI's relationship with m-learning.

The Evolving Landscape of Mobile Learning: Integration with Artificial Intelligence

The evolution of AI-based mobile learning research underscores the importance of recognizing shifting emphases and comprehending the theoretical frameworks underpinning such studies. Understanding these trends and perspectives is crucial for navigating the complexities of this dynamic research landscape, facilitating a deeper understanding of the relationship between AI and m-learning.

The confluence of mobile devices, cloud computing, big data, and other emerging technologies presents a dynamic landscape for educational technology. Current research questions within this domain center around concepts like information technology-supported personalized learning and m-learning (Hamal et al., 2022). These research areas and application opportunities are expanding rapidly, encompassing applications such as games, social media, and extended reality. As a result, the paradigm shift in education and the impact of these developments on learners are continuously reshaping research focus.

The educational technology landscape is experiencing a surge in interest towards personalized learning, anytime-anywhere learning and mobile learning (m-learning). This trend coincides with the proliferation of diverse educational technologies, further fueled by advancements in AI, 5G technology, the Internet of Things (IoT), and cloud solutions (Mohiuddin et al., 2022). These advancements are not only propelling the growth of m-learning but also differentiating and technically enhancing it.

Beyond simply facilitating learner and teacher interaction, m-learning is poised to leverage AI technologies for learner preference analysis. By capitalizing on student data, AI can personalize the learning process and curate a more enriching learning experience. This inherent adaptability of AI opens doors to exceptional educational opportunities for students. In this context, the integration of AI with m-learning presents a significant opportunity to improve educational systems. Current literature also suggests a robust integration of m-learning with AI technology which promising to significantly enhance the learning and teaching processes while enriching research in this field (Adnan et al., 2020; Mahafdah et al., 2023; Martínez et al., 2020; Pereira & Rodrigues, 2013). Fueled by the enduring appeal of both m-learning and AI-based systems, AI-supported m-learning applications hold tremendous potential to revolutionize the teaching and learning process, ultimately reforming the education system (Han, 2022; Luo & Xie, 2018).

The integration of AI into m-learning has revolutionized the learning landscape, offering a unique opportunity to personalize the learning journey. Leveraging the power of AI algorithms, learning experiences can be tailored to individual learner needs. For example the use of chatbots in mobile collaborative learning (Chan & Fung, 2020), predicting learner performance with deep learning, guiding motivational interventions (Mgala et al., 2016), and enabling AI-driven intelligent agents (Henry & Sankaranarayanan, 2010; C.-C. Hsu & Ho, 2012), context-aware, and adaptive mobile learning (Adnan et al., 2021; Al-Hmouz et al., 2009; Ivanova et al., 2022; Nosseir & Fathy, 2020; Pu et al., 2011; Zhao & Long, 2023), use of deep learning models (Deshpande & Mangalwede, 2021; Qiang et al., 2021) can enhance learning experiences and empower learners with ubiquitous access to tailor their learning paths and select appropriate learning objects.

This research aims to analyze the transformations and advancements within AI-based mobile learning research over the past five years. Within the scope of established research questions, relevant articles were identified through meticulous exclusion and inclusion criteria. These articles were then subjected to detailed examination and thematic analysis. The following sections will delve into the research questions and objectives, strategy, and methodology employed. Subsequently, the obtained findings will be evaluated.

Research Questions and Purpose

The burgeoning field of AI-powered mobile learning presents exciting opportunities for personalized and effective education delivery. However, a comprehensive understanding of current research trends and practices is crucial to ensure its continued development and impact. This study aims to address this gap by investigating research conducted between 2019 and 2023. Through the following research questions, we aim to discover in which direction the focus and trends in AI-based mobile learning research are evolving. This investigation will provide valuable insights into the current landscape of AI-powered mobile learning research and lay the groundwork for future advancements in this dynamic field.

In AI-powered mobile learning research conducted between 2019 and 2023:

- RQ1. Which methodologies (e.g. qualitative, quantitative, and mixed) used in research?
- RQ2. What are the characteristics of the participants in the studies including their sample size, age groups, educational levels?
- RQ3. How is the focus of AI-based mobile learning research distributed across different years?
- RQ4. Which foundational theories or theoretical frameworks are utilized in the examined studies?

Method

Recent studies in the last five years (2019-2023) were analyzed in the Web of Science and Scopus databases. The systematic review was conducted in accordance with the PRISMA guidelines (Haddaway et al., 2022). The database was queried with ["Mobile learning" OR "m-learning" OR "Mobile education" OR "Mobile devices in education" OR "tablet learning" OR "smartphone learning" OR "Mobile technology in education" OR "Mobile-assisted"] AND ["generative ai" OR "ai" OR "artificial intelligence"] to search the database by title, keyword and abstract. The searches were limited to open access, full-text articles in English between 2019-2023 (last five years). As a result of the database query, 21 articles were found in the Web of Science database and 38 articles in the Scopus database. The scheme for the selection and elimination process of the studies in accordance with the PRISMA guidelines is shown in Figure 1.

Inclusion And Elimination

In this section, we describe the selection and elimination process of the studies in which our literature review on mobile learning, artificial intelligence, and the intersection of these two fields is discussed in detail. This process aims to identify studies that are relevant to our research questions, methodologically sound and content rich. This review process, in line with our selection criteria, was conducted rigorously to determine the place of the studies within this systematic review and to increase the reliability of the results. These articles were evaluated according to the inclusion and exclusion criteria, and accordingly 20 studies were included in the review.

Inclusion Criteria:

- Articles published between 2019-2023.
- Open access and accessibility to full text in English
- Articles published in refereed journals.

Elimination Criteria

- Combined use of mobile learning and artificial intelligence applications
- Studies focusing on teaching and learning processes.
- Being a literature review, survey or not including experimental studies

A total of 249 articles were accessed with the database query. When eliminated according to the criteria given, 39 articles assessed for eligibility and because of detailed examinations, a total of 20 articles were examined:

- 2 studies were eliminated because they were withdrawn.
- 5 systematic review studies were eliminated.
- 1 was eliminated because it was a book chapter.
- 10 studies were eliminated because they were not AI-supported mobile learning research.
- 1 of them was eliminated because although AI is mentioned in the title, no artificial intelligence technology was used in the research.

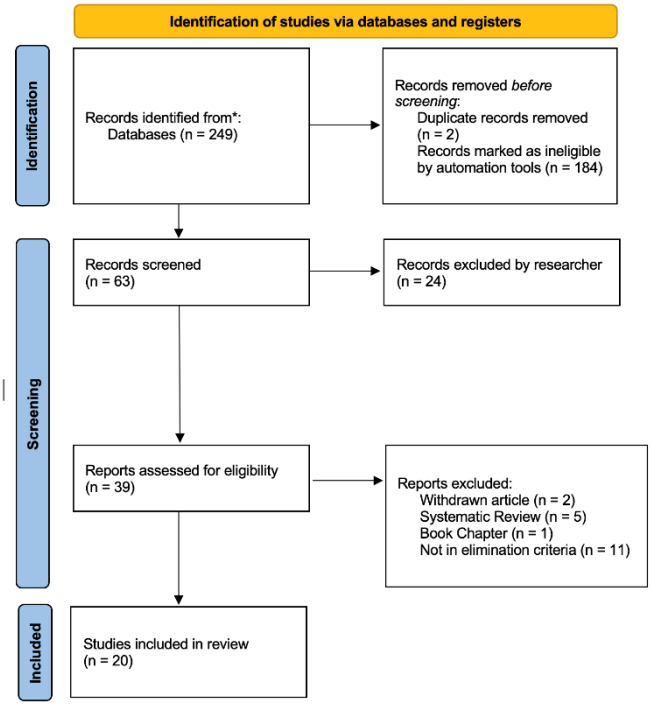

Figure 1: PRISMA 2020 flow diagram. Template from: (Page et al., 2021)

Results

This study examines 20 research articles published between 2019 and 2023 that explore the integration of AI within mobile learning environments. By analyzing participant demographics, research methodologies, and the evolution of AI models across various regions, the research aims to illuminate current trends and practices in AI-powered mobile learning. The following sections will present key findings categorized by the research questions investigated.

RQ1 – Research Demographics and Methodologies

As seen in Figure 2, research has nearly doubled in 2023 compared to previous years. It is expected that the acceleration in the development of AI tools and algorithms, the increase in the variety of tools and their adaptability to various mobile applications, and changes in learning and teaching methodologies will ensure that this research continues to grow in the years ahead.

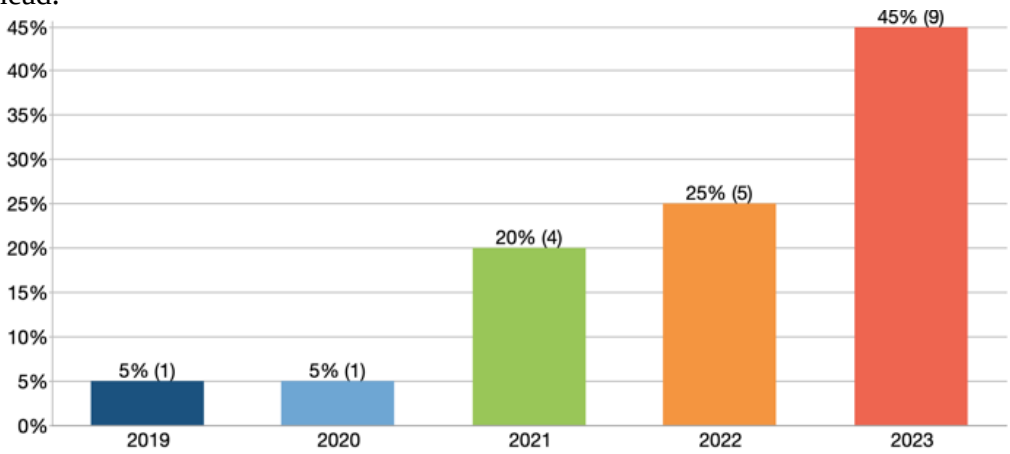

Figure 2: Research by years

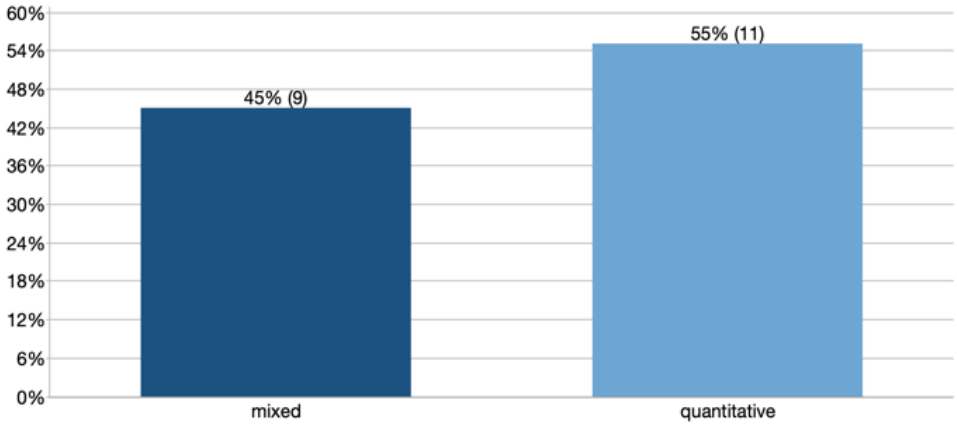

Figure 3: Research methodologies.

In Figure 3 shows the preferred methodologies in the research. The quantitative studies (N=11) are mostly preferred in the analyzed studies. This is due to the use of different AI algorithms in measuring student effectiveness and characteristics and developing personalized learning applications.

RQ2 – Characteristics of the Participants

Thirteen of the analyzed studies utilized experimental or quasi-experimental designs and incorporated human participants. These studies were primarily concerned with evaluating the effectiveness of cognitive services. The remaining seven studies focused on the development, adaptation, and methodological improvements of cognitive services, mobile applications, and algorithms in mobile learning. As these studies did not directly involve human participants, they were excluded from the table. The sample sizes for the thirteen included articles varied primarily between 20 and 99 participants (N=6). The second most frequent sample size range was 100 to 150 participants (N=5).

Table 1: Characteristics of Participants

Size	Characteristics of Participants
>=151	• Of the 495 valid participants, 51.9% were women, 48.1% were men, and the majority (95.8%) were university graduates. • 260 teachers and students from South Africa
100 – 150	• 150 graduate students • 150 undergraduate students • 108 4th grade students • 103 college students • 142 adult (age between18 -80)
20 – 99	• 20 undergraduate and graduate students from diverse departments in local university • 60 nursing students (30 experimental groups and 30 control groups) • 70 undergraduate students from diverse departments in China • 35 Sociology Students • 30 college students from USA • 58 students

RQ3 – Foundational Theories and Theoretical Frameworks

The study examined the theoretical frameworks employed within the selected research, with a particular focus on how the concept of 'mobile learning' itself was conceptualized. While all studies centered on mobile learning applications, further coding identified those that explicitly treated 'mobile learning' as a theoretical framework.

The specific frameworks utilized exhibited variation across publication years. In 2022, studies predominantly drew upon frameworks associated with interface design, research and development models, language learning, and student learning characteristics. Conversely, research in 2023 demonstrated a shift towards frameworks encompassing augmented reality (AR) and virtual reality (VR) mobile tutoring systems, social network-based interaction, and diverse learning approaches. Table 2 offers a comprehensive overview of the theoretical foundations and frameworks identified within the studies.

Theories and frameworks establish the general guiding principles and fundamental concepts of the research. They provide guidance on how to collect or analyze data. By helping to formulate a particular topic or phenomenon with existing knowledge and literature, hypothesis development can help make sense of that topic or phenomenon. It provides guidance in showing how the relatively newer artificial intelligence literature and the theories and frameworks developed on learning, and especially mobile learning, relate to interdisciplinary study and

increased knowledge accumulation. This ensures consistency between studies and scientific progress.

The analysis provides answers to the questions sought over time and identifies which theories and frameworks are intended for specific problems. This comparative analysis examines the evolution of research theories and frameworks in AI and mobile learning from 2019 to 2023. The findings reveal a shift in focus towards personalization, engagement, and the learner experience.

Table 2: Theoretical Foundations and Frameworks employed in selected researches.

2019	2020	2021	2022	2023
• Mobile Learning • Mobile Cloud Computing • Decision Tree Learning • Context Aware Learning	• Pedagogical agents • Gamification • Intelligent tutoring Systems	• MOOC collaboration activities, "col-mooc" • Technology-mediated teaching–learning • Personalizing learning • Self-regulated learning • Micro-learning activities • Intelligent Tutoring Systems • Fuzzy TOPSIS • 4D model • Digital native • Plasticity of user interface • SVM (Support Vector Machine) classifiers • Cross-cultural usability • Ubiquitous Learning • Heutagogy approach • Mobile learning	• Instructional design • Contextual relevance • Characteristics of learning convenience • Ai based adaptive interface app. • Ciaui framework • Uesugi the 5-factor model • The big-five personality traits • Behavioral characteristics • Users' personality traits • Authentic and ubiquitous learning • Technology-supported language learning • Ai-enabled english language learning (AIELL) • Ubiquitous learning • Deep learning • Intelligibility • Ai-powered mobile applications (ai apps) • Kachru's influential three-circle model • Lingua franca (elf) • Mobile-assisted language learning • Computer-assisted language learning (call) • Automatic speech recognition (asr) technology • Mobile learning • Context-aware learning	• Social network-based interaction in language learning • Mobile-assisted language learning (mall) • Ar-based mobile touring system • Digital well-being • Positive design • Ai-enabled english language learning (aiell) • Crossword puzzle strategy • Critical thinking skills • Active learning • Online chatbot learning method. • Marougkas' framework for personalized vr learning environments. • Flow theory. • Self-determination theory • Diffusion of innovations • Uses and gratifications (u&g) theory. • Smart mobile learning (sml) • Intelligent m-learning system • Internet-assisted or e-enabled education • Cognitive learning services • Mobile technology's usefulness in education • Usability of mobile apps • Cognitive analytics • Mobile learning • Technology acceptance model (tam)

Table 3-Researches by year and methodology (Q: quantitative, M:Mixed)

Year	Research Aims	Method
2019	• A clustered-based machine learning algorithm called DBSCAN on students' context data stored in the Google Firebase database cloud to discover the relationship between learning context variables • Creating a learning environment where they can practice and solve programming problems using mobile devices to improve their computer programming skills (Adnan et al., 2019)	Q
2020	• Evaluating 47 educational chatbots using Facebook Messenger platform based on quality attributes such as teaching, humanity, emotion and accessibility based on analytic hierarchy process (Smutny & Schreiberova, 2020)	Q
2021	• Development of a culturally inclusive, ubiquitous M-Learning platform ("Mobile Academy") with an AI-based adaptive user interface • Cross-cultural usability using a combination of artificial intelligence and the flexibility of user interface design techniques • Performance and cross-device evaluation from SVM classification results (Miraz et al., 2021)	M
	• Developing a mobile learning application, Sosiopedia, using the hetagogy approach to promote the learning of sociological theory. • Students choose the way of learning • Application development to enable active and collaborative interactions (Perguna & Widianto, 2021)	M
	• Creating optimal social media applications for u-learning in schools • Suitability of the social media application for ubiquitous learning • (Sam et al., 2021)	Q
	• Educational use of chatbots as a resource to promote more personalized and integrated learning in different virtual learning environments • Chatbots as teaching resources, more flexible digital environments for anytime, anywhere learning (Vázquez-Cano et al., 2021)	Q
2022	• KoE : Korean Accent English LFC: Lingua Franca Core NSs: Native English Speakers Native English speakers and AI applications difference on finding KoE • How is KoE intelligibility for human listeners and AI applications? (Chung & Bong, 2022)	M
	• To analyze students' learning situations and interests by integrating deep learning technology into a mobile English learning platform • With this integration, improve learning efficiency by delivering personalized content based on student needs and interests. • Modeling student behavior • Create a language vector feature extraction mechanism and a translation quality assessment model to provide intelligent assistive editing and improvement of students' English grammatical expressions and English speech (Cui & Li, 2022)	Q

	• Artificial Intelligence Assisted English Language Learning (AIELL) • AIELL system development process to facilitate students' acquisition of English vocabulary and grammar • Key features of the AIELL system • The relationship between mobile learning environment design features and student engagement (Jia et al., 2022)	M
	• Overall usability of culturally inclusive adaptive user interface • Evaluate the cross-cultural inclusiveness of the prototype • Collect data to evaluate the performance of SVM classifiers (Miraz et al., 2022)	M
	• To design and develop a mobile teaching model for English reading based on the K-Means algorithm. • To provide a platform for individualized learning, improve learning efficiency and stimulate students' interest in English reading. • It uses k-means algorithm to analyze the English reading teaching mode and explore the relationship between test questions and test results. • K-means technology can extract abundant, unexplored, and potentially useful information from Web service site logs. • To learn students' web visiting behaviors and paths, to find learning and teaching rules, and to find personalized learning features and requirements for students. (Peng, 2022)	M
2023	• Analyzing the use of English vocabulary tests in cognitive web services platforms for English mobile learning • Understanding user buying behavior and the impact of app-enabled approaches using machine learning • Address data requests and information activities on mobile platforms for English vocabulary learning. • Proposes and evaluates AI-EVTR model based on machine learning to improve application memorization technique. (Alsanousi et al., 2023)	Q
	In Artificial Intelligence Supported Mobile Learning Applications: • user experience • Impact of usability issues on user satisfaction, effectiveness and efficiency • Explore the most common usability issues related to AI (J. Chen, 2023)	M
	• Investigating mobile learning implementation in MI-IHEES using cognitive web services for data analytics • Impact on usefulness, student academic achievement, attitudes, and perceptions • Identifying the advantages and challenges of mobile learning in English • Developing innovative mobile applications for English classroom teaching (Gao, 2023)	M
	• Intention to continue Smart Mobile Learning in relation to perceived intelligence, convenience, perceived enjoyment, concentration, status, achievement and education. (M.-H. Hsu et al., 2023)	Q
	• Use of Termbot to improve students' medical terminology (Liao, 2023)	Q
	• AI-Pengtalk's contribution to improving students' English proficiency and attitudes towards English (Um et al., 2023)	Q
	• The impact of a positively designed chatbot on graduate students' APA7 style referencing skills and students' digital well-being in a mobile learning environment (Zaky, 2023)	Q

	• Designing IM-ELS and IM-ELS method to provide high accessibility, improve student performance, predict student behavior and learning outcomes (Zhang, 2023)	Q
	• EFL learners' perceptions of social network-based interactive activities when practicing oral English with AI speaking applications? • How can social network-based interactions help EFL learners to practice spoken English with AI speaking applications? (Zou et al., 2023)	M

As a result of the elimination according to the given criteria, there is one study each in 2019 and 2020. In this section, while trying to analyze the theories and approaches taken as the basis in those particular years while seeking an answer to the research question, supported by themes in order to see the change over the years more clearly, we refrain from generalizing for 2019 and 2020 due to the small number of studies. For future research, the scope of the studies in 2019 and 2020 analyzed in detail in the *Table 3*.

a) Early Focus on Technical Infrastructure (2019):

The 2019 landscape reflects a concentration on the technical underpinnings of mobile learning. Frameworks like Mobile Cloud Computing and Decision Tree Learning dominated research, suggesting an exploration of data storage, processing, and decision-making algorithms suitable for mobile learning environments. Additionally, Context-Aware Learning emerged as a key concept, indicating an interest in tailoring learning experiences to learners' situations.

b) Pedagogical Innovation Takes Center Stage (2020):

By 2020, the focus shifted towards pedagogical approaches. Frameworks such as pedagogical agents and gamification gained prominence, signifying a growing interest in using AI-powered virtual characters and game mechanics to enhance learning engagement. The continued presence of Intelligent Tutoring Systems underscores the ongoing exploration of AI for the development of personalized learning pathways, further emphasizing the importance of adaptive and individualized instruction in contemporary educational settings.

c) Personalized and Intelligent Mobile Learning (2021)

By analyzing the theories and frameworks used in research in 2021, we can identify that the focus of research this year was on personalized learning and intelligent learning systems. Personalized learning refers to learning experiences that are tailored to the individual student's needs and learning style(Ling & Tan, 2020). The theories in research include personalized learning, self-regulated learning, micro-learning activities, intelligent tutoring systems, Fuzzy TOPSIS, and the 4D model. In addition, research based on artificial neural networks, support vector machine (SVM) classifiers in relation to the intelligent learning system aims to optimize the learning experience by predicting students' performance. In conclusion, research in 2021 focused on how AI can be used to create intelligent mobile learning environments that are tailored to the individual needs of students and optimize their learning experience.

d) Convergence of AI and Mobile Learning (2022):

2022 marked a significant convergence of AI and mobile learning. Frameworks like the CIAUI Framework and Uesugi's Five-factor model highlight the integration of AI to understand user personality traits and tailor learning experiences accordingly. This aligns with the increasing use of AI-based adaptive interface apps. Furthermore, the continued interest in mobile-assisted language learning (MALL) and computer-assisted language learning (CALL) demonstrates the ongoing exploration of mobile technologies for language acquisition.

e) Social Interaction and Holistic Learning (2023):

The latest research trends in 2023 reveal a growing focus on social interaction and holistic learning. Frameworks like social network-based interaction and online chatbot learning methods showcase an interest in leveraging social technologies to facilitate collaborative learning. Additionally, the emergence of positive design and flow theory suggests a shift towards creating positive and intrinsically motivating learning environments.

In conclusion, the analysis of research theories and frameworks from 2019 to 2023 reveals a clear evolution in AI and mobile learning research. The field has moved beyond a purely technical focus to embrace learner-centered approaches, personalization, social interaction, and the creation of holistic learning experiences. Previous studies on m-learning research have primarily focused on the technology aspect. However, there is a shift towards optimizing the learning process (Hamzah et al., 2020; Yıldız et al., 2020). Although we refrain from generalizing between 2019 and 2020, given the quantity of articles, we can assert that our findings are consistent with the literature. In the post-2020 years, it can be argued that with smart learning systems, students' particular characteristics are found and learn autonomously, and the learning system is tested to verify that the learning system is fluently directed with tailored feedback and improvements. This emphasizes the necessity of utilizing AI's full potential in m-learning (Asadullah et al., 2023; Crompton & Song, 2021; Hamzah et al., 2020; Sarker et al., 2021), and supports previous studies that calls for study based on learning outcomes and learning theories(Liang et al., 2021; Mayer, 2020). These findings signify a promising future for AI and mobile learning, where technology empowers personalized and engaging learning opportunities for all.

RQ4 – Change in Research Focuses by Years

A literature review was conducted on Artificial Intelligence (AI) and Mobile Learning (M-Learning). A diachronic analysis of research focus revealed the following trends: Included articles were examined for research questions and objectives across publication years. Table 3 presents a thematic breakdown of these objectives by year and research methodology, utilizing codes generated in MAXQDA 24. These codes were interpreted in relation to the algorithms employed in M-Learning, the functionalities of the developed tools, and the learner data incorporated.

Table 4 shows how the research focuses of AI based mobile learning research changed between 2019 and 2023. Since the research focus was coded in more than one study, the numbers vary from the number of articles. We added the relationship of research focus and years in Figure 4

which made with MAXMaps in MaxQDA24. In line with this cross analysis, the following inferences were made:

The evident from the growing number of publications (Table 4) in areas such as "AI Enabled Mobile Language Learning" and "Use of Contextual Information in Learning" shows that the most notable trend is the increasing interest in the role of AI in mobile learning. The trend of AI-enabled mobile language learning is driven by widespread use of mobile devices and the advancements in AI Technology (Arvanitis & Krystalli, 2021).

Table 4: Change of Research Focuses by years.

Research Focus	**2019**	**2020**	**2021**	**2022**	**2023**	**SUM**
Learning System with AI					2	2
User Experience					1	1
Developing Mobile Teaching Model				1	1	2
AI Enabled Mobile Language Learning				4	4	8
Mobile App Development			2		1	3
Ubiquitous M-Learning			3			3
Adaptive UI Development with AI			1	1		2
Use of Educational Chatbots		1	1		1	3
Use of Contextual Information in Learning	1					1
SUM	**1**	**1**	**7**	**6**	**10**	**25**

Findings that AI-based mobile learning improves language outcomes and student satisfaction (Chen et al., 2021) and increases English proficiency (Arini et al., 2022) when combined with teacher intervention and collaborative design (Yang & Kyun, 2022) also show the potential of this integration for learning and improving student satisfaction. The integration of AI into mobile learning is leading to innovative applications such as personalized learning experiences, adaptive user interfaces, and chatbots.

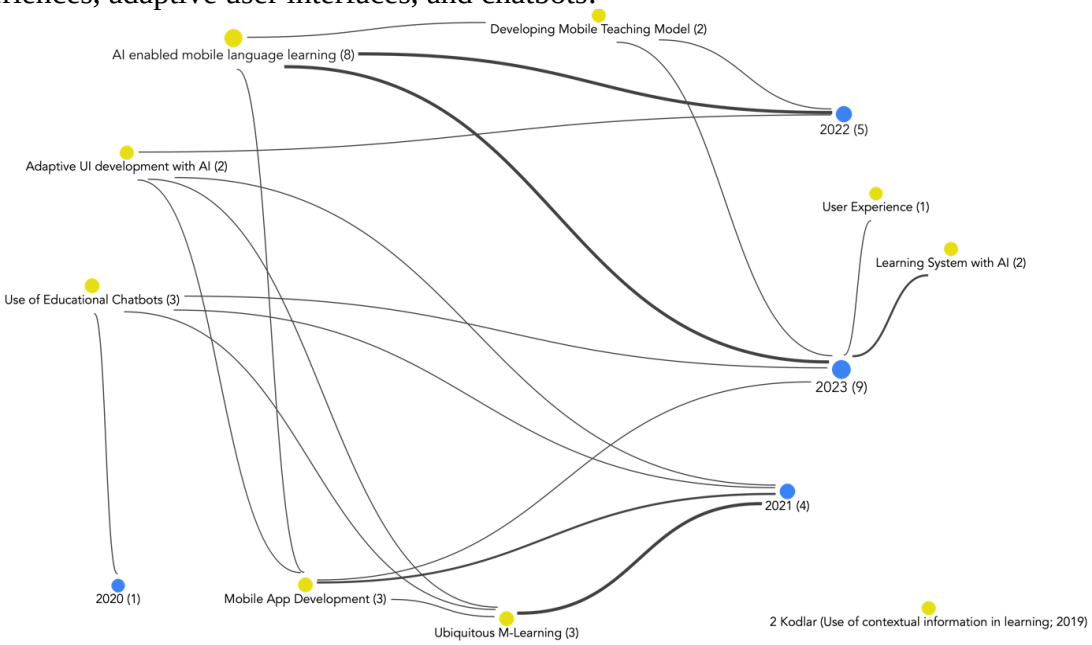

Figure 4:Relationships between Research Focuses

User experience research continues to be of interest in both work and leisure contexts (Simsek Caglar et al., 2022). As the variety of devices and developed software increases, the importance of user experience research persists. Research in this field has shown significant growth, particularly with a focus on usability, virtual reality, human-computer interaction, and augmented reality (Zuo et al., 2023). Therefore, usability testing and user feedback analysis remain crucial in research and development processes for artificial intelligence-based mobile learning studies that include digital products aimed at increasing accessibility and ease of use (Vasilieva & Khisyukov, 2023). It is also evident that user experience research is a continuing area of interest in developing user-friendly mobile learning environments that enhance learner engagement and motivation.

The identification and evaluation of good teaching practices in mobile learning have led to the development of specific models (Romero-Rodriguez et al., 2020). By developing practical, flexible models with the opportunities offered by artificial intelligence, students' learning experience and motivation can be increased (Dakir et al., 2021). The studies in Table 4 for 2022 and 2023 are indicative of an ongoing quest to effectively deliver mobile learning. There are also studies in areas such as "Mobile App Development," "Adaptive UI Development with AI," and "Use of Educational Chatbots". These areas hold significant potential for the future development of mobile learning.

AI-based mobile learning research is rapidly evolving, and the research focus in this field is changing over time. Based on findings the key points of research focuses can be seen on the timeline in Figure 5:

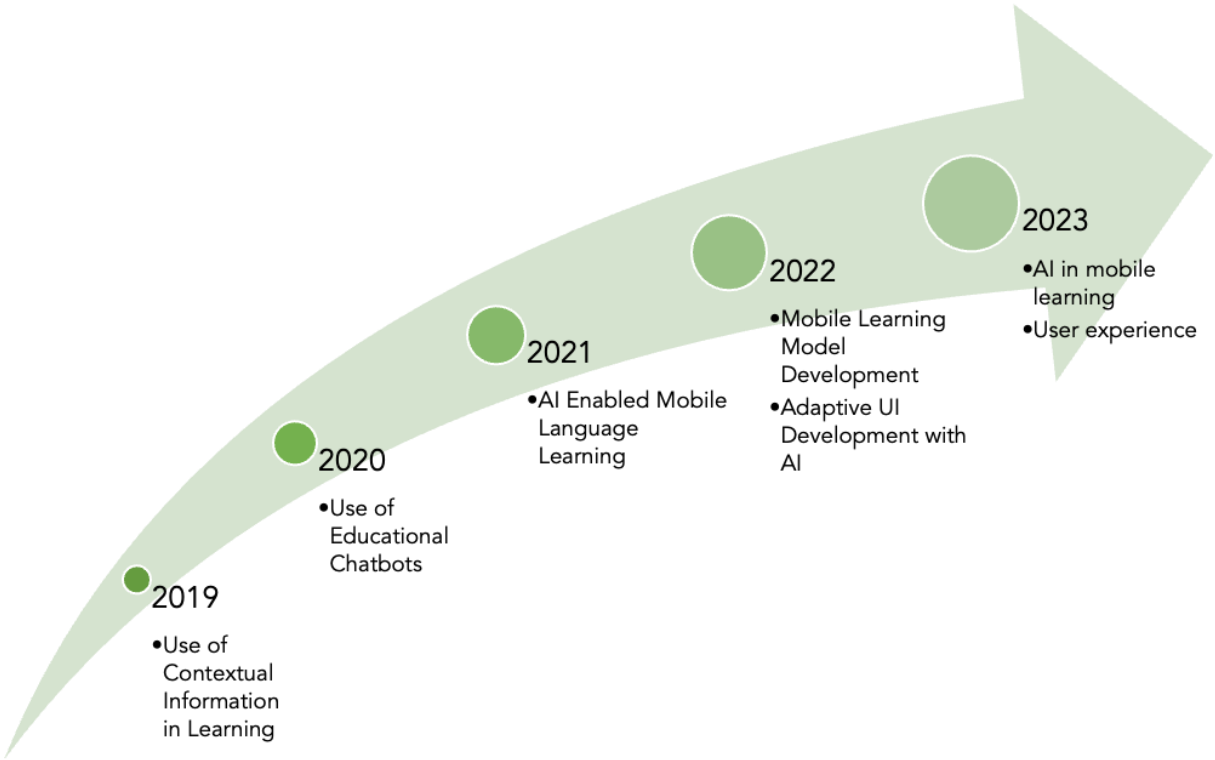

Figure 5:Research Focus Key Points' Timeline

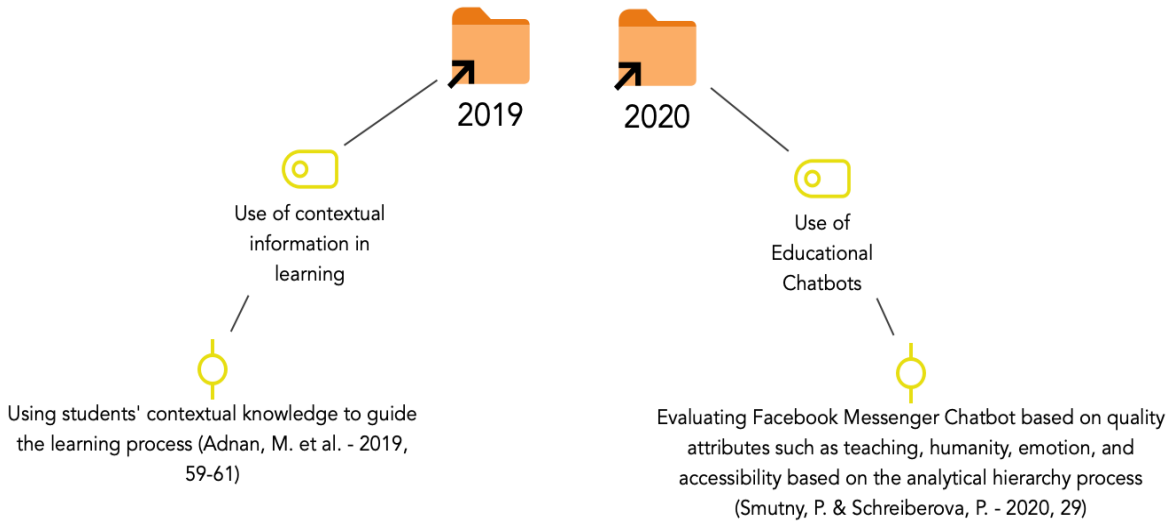

Figure 6:Research Focus in 2019-2020

Figure 5, *Figure 7*, *Figure 8* and *Figure 9* show research focuses and what types of problems they address within that focus. As depicted in *Figure 6*, research conducted in 2019 explored the utilization of students' contextual information within the learning process. It appears that subsequent years lacked studies focused on this aspect. This suggests that challenges related to technology, data access, and insufficient resources may hinder the continuation of such research.

The analysis shows that the diversity of research focuses has increased since 2021, and these focuses have become more diverse in the following years. In 2021, the development of culturally inclusive m-learning platforms and the widespread use of performance and cross-device evaluations based on support vector machines (SVM) classification results have gained importance (Table *3*). Furthermore, studies on educational approaches have adopted the heutagogical approach and evaluated students' opportunities to choose their own learning paths. Application development and personalized learning studies are gaining momentum. Flexible digital environments that enable learning anytime, anywhere, and the use of chatbots as resources for this purpose are also becoming popular. There has been a shift from a technology-oriented approach to educational approaches and application usage in recent years (Figure 7).

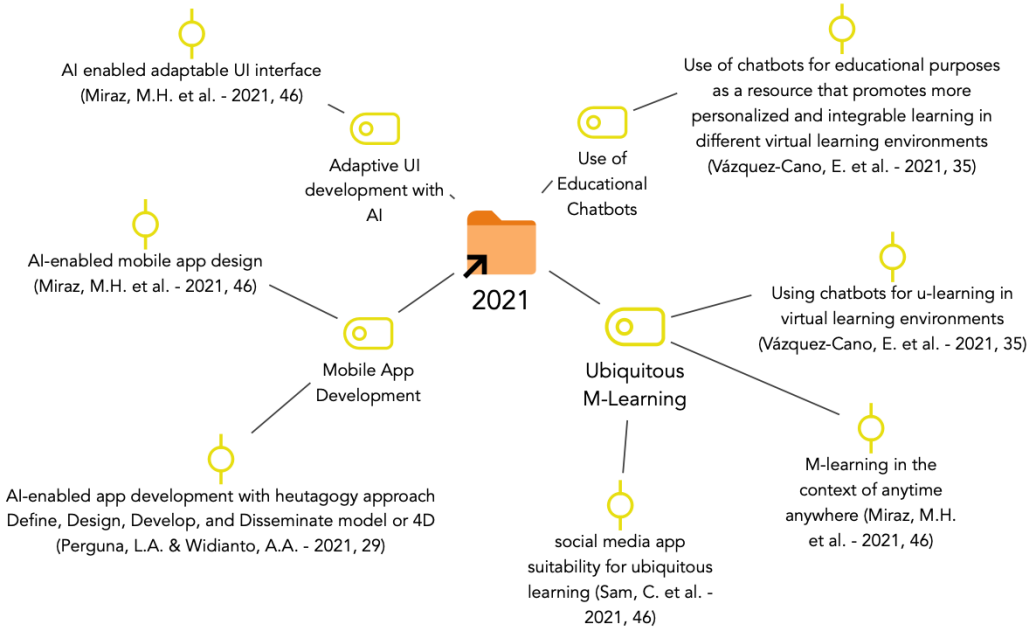

Figure 7: Research Focus in 2021

Upon examining *Figure 8*, it is evident that there will be a significant increase in studies related to language learning in 2022. Several issues such as the use of K-Means algorithms, the development of the AIELL system, and the creation of culturally inclusive adaptable interface designs are being addressed due to the intercultural nature of language learning. Additionally, the research is covering a wider range of topics.

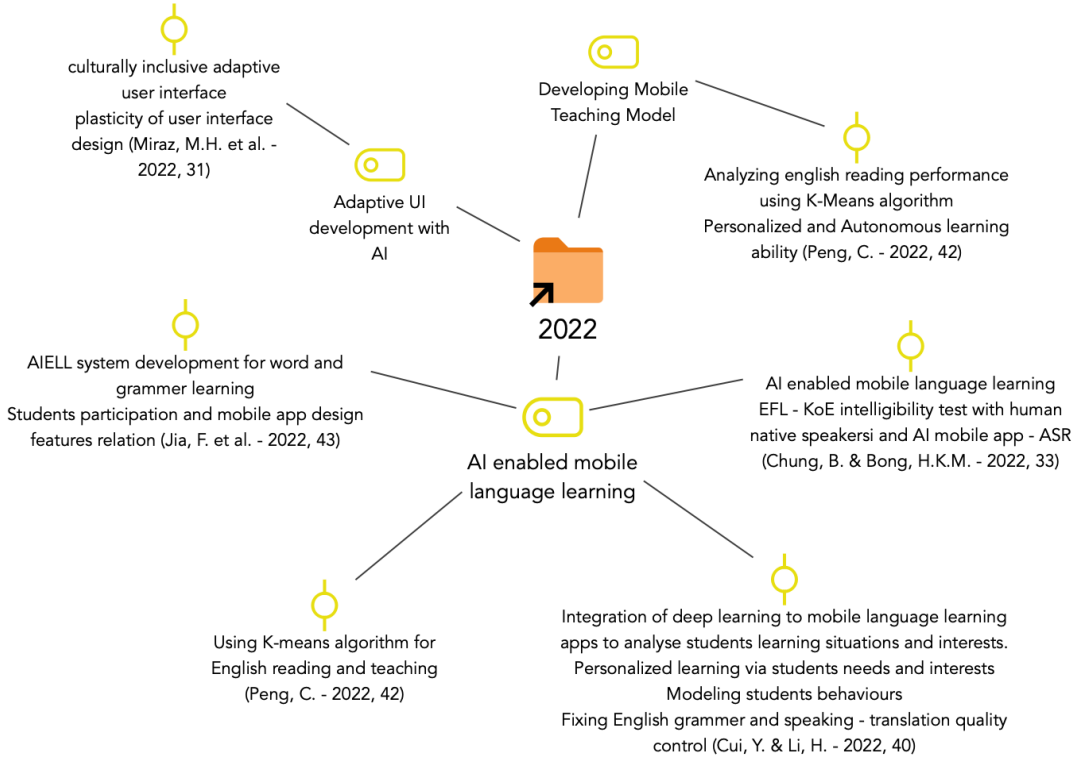

Figure 8: Research Focus in 2022

Studies in 2023 (*Figure 9*) explored various aspects of mobile learning, AI applications, and English language acquisition. Researchers investigated the integration of English vocabulary tests into mobile platforms, analyzed user experience in AI-supported learning apps, and assessed the impact of mobile learning on student performance and intention to continue learning. These studies aimed to improve usability, effectiveness, and outcomes in mobile learning environments.

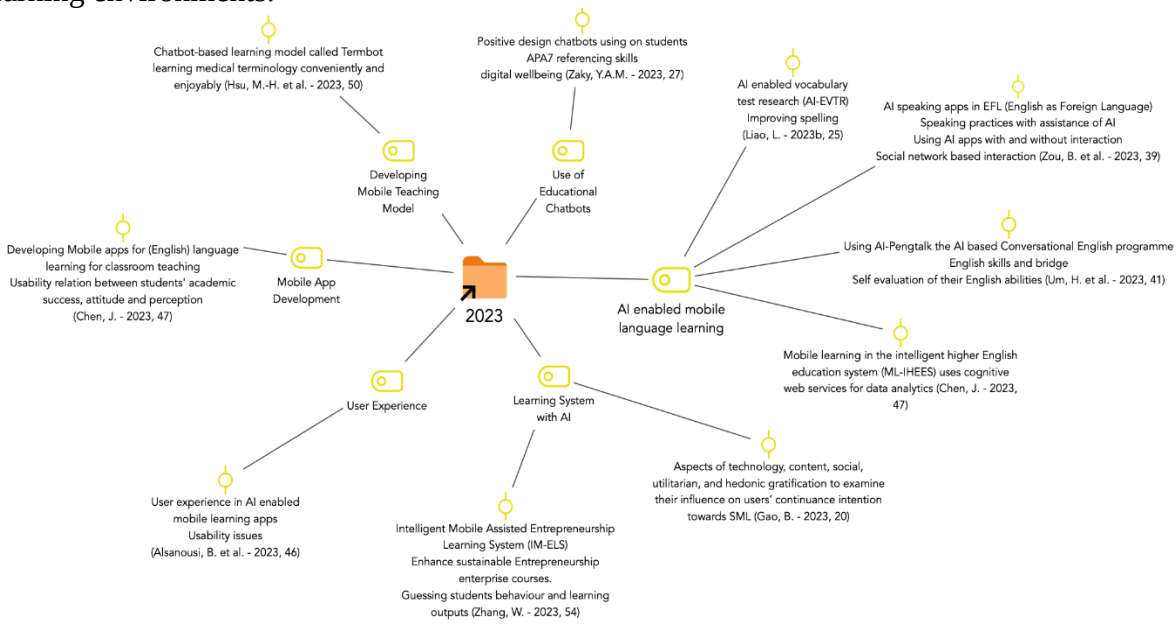

Figure 9: Research Focus in 2023

Discussion

This literature study has led to an analysis of the current state of research on the application of artificial intelligence (AI) in mobile learning, as well as a presentation of the main research foci, methodologies, and underlying theories and frameworks. The optimization of personalized intelligent learning settings and the technical elements of diverse AI technologies are the main areas of research, which is growing yearly. Given that algorithms and data sets are among the technologies employed, it follows that mixed and primarily quantitative approaches are favored.

It can be stated that in studies involving human participants, medium-scale sample sizes are chosen by effectively evaluating in terms of applicability, accessibility, and consistency, even though some studies do not use human participants and instead concentrate on application or algorithm development. Enhancing personalization, engagement, and the learning experience, as well as creating and applying algorithms for these, have been the main goals of the integration of m-learning and artificial intelligence over the years.

Conclusion

Every day, a wider range of devices and digital technologies are developed, and paradigms in education keep shifting. With various technological, economic, and socio-cultural limitations, it was unpredicted that we would have the opportunity to achieve more in terms of education and training in the mobile environment than in the traditional classroom setting. Nevertheless, this is the reality we now face. Technologies that once became an extension of

an individual's body are now vital elements that influence the dynamics of society. The data gathered may provide more information than the interaction in a classroom environment since the rate of engagement increases in digital environments that relate to the individual's life.

As a result, it is obvious that AI algorithms will significantly improve education stakeholders' efficiency by managing this data in context, personalizing it for each individual, and making it beneficial to them. Cybersecurity and ethics concerns arise when it comes to data in mobile settings with considerable usage and interaction. It is suggested that more thorough qualitative research be done in the future based on learning theories, considering the cyber security and ethical aspects of using artificial intelligence in mobile learning.

Declaration of Interest

Conflict of Interest: The authors of this publication declares there is no conflict of interest.

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