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Original Article

Self-Regulation of Learning in Higher Education Mobile Learning Landscape: A Review

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Abstract: Mobile learning has emerged as a convenient approach that enables learning anytime and anywhere in today's fast-paced world. Previous reviews have examined mobile learning in higher education or mobile self-regulated learning interventions across different educational levels; however, few studies have specifically explored the relationship between mobile learning and self-regulated learning at the higher education level. This article adopted a systematic literature review using the Scopus database, including 16 articles selected for bibliometric and content analysis. The results indicate that only limited research has systematically investigated self-regulated learning in mobile learning environments. Most reviewed studies report positive effects of mobile learning on self-regulated learning and of mobile self-regulated learning on learning outcomes. Nevertheless, the potential of mobile learning interventions remains largely underexplored. This study highlights the need for further research on pedagogy, assessment, and theoretical frameworks to inform the design of instructional strategies and tools that enhance the effectiveness of mobile learning.

Keywords: Mobile learning, higher education, self-regulated learning, educational technology.

1. Introduction

Mobile learning (m-learning) refers to the model where learners use the Internet and mobile technologies to access resources and perform tasks on the go [1]. In fact, Mobile devices have become so prevalent on university campuses that students and faculty often connect multiple devices, such as mobile phones and laptops, to campus Wi-Fi daily [2]. Students utilize mobile-specific educational applications like Duolingo, Quizlet, and Evernote, as well as general platforms like YouTube and ChatGPT, for learning. The learning platforms which have been best accessed in website browsers such as Coursera, Udemy, LinkedIn Learning have also been optimized for mobile use. Recognizing the need for access to up-to-date knowledge, Vietnam recently made Internet speed a standard for higher education institutions [3].

A key issue arising is to reinforce student autonomy in these mobile learning environments. Concerns have been voiced regarding cognitive overload, stress from

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excessive technology use [4], course structure and pedagogy alignment [5] or time management struggles [6]. However, mobile learning offers opportunities for students to exercise autonomy and regulate their own learning. A systematic review highlighted how mobile learning can empower students by using learning analytics to personalize their learning [7]. While this review focused on language learning, a broader meta-analysis examined self-regulated learning across various educational levels and platforms, including mobile learning [8]. However, there is still a lack of systematic literature reviews specifically analysing university students' self-regulated learning (self-regulated learning) in mobile platforms. This study aims to address that gap through several research questions.

RQ1: How has the number of articles changed throughout the years and in which countries were the studies conducted?

RQ2: In what subject has mobile learning been studied in higher education?

RQ3: What SRL theoretical frameworks and dimensions have been studied in relation to what types of mobile learning?

RQ4: What are the purposes of the studies?

RQ5: What methodologies have been employed to study SRL in mobile learning environment in higher education?

2. Literature Review

2.1. Self-regulated Learning

Self-regulated learning (SRL) is an ongoing decision-making process comprising smaller learning cycles aimed at achieving academic goals. Each cycle involves three phases: Forethought, Performance, and Self-Reflection [9]. In the Forethought phase, learners analyse tasks, set goals, and devise plans influenced by self-motivation beliefs such as self-efficacy and interest in the task. SRL is often studied alongside self-efficacy, particularly in digital environments [10-13] and students' readiness for mobile learning [14].

During the Performance phase, learners execute tasks involving self-control and self-observation. Self-control includes cognitive tasks, with time management and help-seeking being key strategies in online learning context [15]. Self-observation involves tracking progress through methods like notetaking, study logs, and test results, enhanced by real-time learning analytics [16].

In the Self-reflection phase, learners evaluate their progress and outcomes, analysing effective and ineffective strategies. This involves reactions of self-satisfaction or dissatisfaction and adapting or defending against results. Without frequent reflection, students might not identify improvement areas or may blame external factors for poor outcomes. A study found that students receiving weekly learning analytics reported higher SRL skills and academic achievement [17], highlighting the importance of regular self-reflection supported by personalized analytics.

It is stated in [18] that the framework of Zimmerman and Moylan (2009) is not the most used for studying SRL in online platforms. However, it is straightforward and encompasses cognitive, metacognitive, motivational, and behavioural dimensions of SRL. This makes it suitable for analysing SRL skills across different studies. Our review employs this cyclical phase model to examine the SRL skills in the articles reviewed.

2.2. Mobile Learning

Online learning is an umbrella term encompassing various concepts tied to technology and time, often contrasted with traditional classrooms [19]. Despite its frequent use, a unified definition is lacking, leading to the interchangeable use of "online learning" and "mobile learning".

Mobile learning, emerging later than online learning, extends it to wireless/handheld devices with technologies like Short Message Service (SMS) and Wireless Access Protocols (WAP) technologies [20]. Ozdamli and Cavus (2011) defined mobile learning with seven characteristics: “Ubiquitous, Portable size of mobile tools, Blended, Private, Interactive, Collaborative, and Instant information”. They

also outlined five elements: Learner, Teacher, Content, Environment, and Assessment [21]. Mobile learning can thus be examined from multiple perspectives, including as a learning platform or mode.

So far, mobile learning has been indicated to help enrich student engagement and motivation [22], facilitate self-regulation through easy access to information, and promotes collaboration and communication, enabling constant feedback [23].

2.3. Inclusion Criteria

We set out the following inclusion criteria:

i) Investigating Self-regulated learning and Mobile learning as scientific constructs, with elaboration of definitions and related literature;

ii) Investigating these two constructs at higher education level;

iii) Mobile devices include portable devices such as mobile phones, tablets and can include laptops;

iv) Being a primary research article. Meta-analysis and reviews are excluded. Other types of publications such as book chapters, conference proceedings are also excluded;

v) Being published in English.

3. Data Collection

3.1. Search Strategies

We used Scopus as the sole research database for this review with the following search string: TITLE-ABS-KEY ("mobile learning" AND "Self-regul*" AND "university" OR "higher education" OR "college") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (LANGUAGE, "English")). At this stage, 26 articles were found.

3.2. Research Selection

Based on the selection criteria, three articles were removed as they are either a meta-analysis [8], an integrative literature review [14] or a bibliometric analysis [7]. Upon reading the full text, seven other articles were removed as self-regulation of learning in these articles was not elaborated as an independent scientific construct but rather a term to describe the mode of studying by oneself (control group) in contrast to studying with support functions of mobile learning (experimental group) [24] or as a skill to be likely required from and benefitting from online learning [25-29] . Thus, the final sample consisted of 16 articles.

4. Data Analysis

For research question 1, bibliometric data was analysed using excel formulas such as Pivot table. For the other research questions, content analysis was employed using a grounded theory coding with a continuous comparative method [30]. First, themes were established based on research questions. Then, the authors read each article to take notes for each theme. During notetaking, for each theme, keywords emerged as open codes and compared with the theoretical frameworks mentioned in Section 2 and among one another to establish final codes. The codes are presented in the Table 1 below.

Table 1. Codes to categorize and analyse content of the articles

Research questions	Codes	Description
RQ2: Subject	Not stated	In these studies, the subjects were not stated or not clarified to refer to online learning in general (of any subject or several subjects in the participants' degree program).
	Language learning	These studies investigate mobile learning of languages.
	Medical subjects	These studies investigate mobile learning of medical subjects.
	Computer Science (CS) related subjects	These studies investigate mobile learning of computer science related subjects.
	OER and technologies	These studies investigate mobile learning of a particular course into OER and technologies.

Research questions	Codes	Description
RQ3: Theories of SRL	Butter and Winnie (1995)	The model which emphasizes the importance of feedback, internal and external, in self-regulation of learning. This can be said to provide grounds for the Winnie and Hadwin's COPES model in 1998.
	Winnie and Hadwin (1998)	The COPES model which frames SRL in four steps namely: defining the task, setting goals and plan, enacting study tactics, and adapting metacognitively.
	Zimmerman (2000)	The cyclical model of SRL consisting of three main phases: Forethought, Performance and Self-reflection.
	Nota et al., (2004)	The 15 categories of SRL strategies including strategies such as: self-evaluation, rehearsing and memorizing, reviewing records, seeking social assistance.
	No framework	These studies do not clarify a theoretical framework. They only provide a general understanding or a definition for SRL or identify key characteristics of the concept.
RQ3: SRL skills/ dimensions	Self-evaluation (Reflection)	The articles either mention SRL as an integrated skill or focus on one or several strategies. After coding, the author of this review adds the bigger phase in the bracket the bigger phase according to the cyclical model of SRL [31] to serve both skill and phase analysis.
	Self-monitoring skills (Performance)	
	Help seeking (Performance)	
	Keeping records and information seeking (Performance)	
	Time management (Performance)	
	Planning (Forethought)	
	Motivation	
	As an integrated skill	
RQ3: Representation of mobile learning	Electronic devices	Mobile devices are mentioned as electronic devices generally used to access information, course contents and perform learning tasks.
	Learning applications - Created-for-mobile	M-learning in the form of learning applications, designed primarily to be used on mobile phones.
	Interventions - Leaning analytics	M-learning in the form of learning analytics to inform learners of progress or to adjust recommendation of resources.
	Interventions - Mobile application to assist in help-seeking	M-learning in the form of a functional application on mobile phones connecting learners with peers to seek assistance.
	Interventions - Reflection amplifiers	Mobile learning is approached from the capability of providing reflection prompts to increase awareness of their learning process.
RQ4: Purpose of the study	To identify learning behaviour	These types of exploratory research investigate the learning behaviours, perceived challenges and opportunities of learners on mobile learning environment in terms of self-regulated learning.
	To identify perception	
	To evaluate impact of mobile learning	These types of impact evaluation research aim to assess the influence of mobile learning in general, a learning

Research questions	Codes	Description
	To evaluate impact of mobile learning applications	application or an intervention on self-regulated learning together with one or several indicators of self-efficacy, learning outcomes.
	To evaluate impact of mobile learning intervention	
RQ5: Methodology	Interviews	These studies use interviews alone to investigate students' SRL.
	Log data	These studies use log data alone to investigate students' SRL
	Questionnaire - established	These studies used previously established and validated SRL questionnaires as the instrument to evaluate SRL.
	Questionnaire - author-proposed	These studies are based on other frameworks or scales to propose a questionnaire of their own. This questionnaire worked independently or was coupled with other instruments such as reflection notes, interviews or focus group.

5. Results

5.1. Bibliometric Analysis

RQ1: How has the number of articles changed throughout the years and in which countries were the studies conducted?

Publication year.

The first article written about the topic was in 2015. It was to assess the impact of self-efficacy and self-regulation on student achievement in a GPS-based mobile learning application [10]. The exploratory study provided insights into and called for further efforts in designing applications for university students. However, there was only one more article in 2016 and no article in the topic for the next two years (see Figure 1). The number of articles stayed at only 1-2 articles annually until 2021 before rising to three articles in 2022 and six articles in 2023.

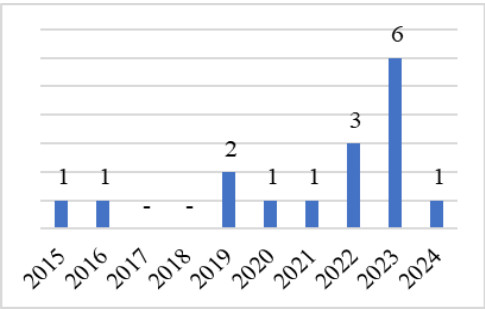

Figure 1. The number of articles by year of publication.

Publication by country of correspondence affiliation.

In the Asian countries China, Taiwan, Malaysia, Singapore, Vietnam, Indonesia, Turkey and Russia (note that the two last countries have territories in both Europe and Asia), a total of 10 studies have been conducted. Only two studies were carried out in European countries, Greece and Spain; and only one study in all Oceania (Australia). Meanwhile, in the United States alone, there have been three studies (see Figure 2). This indicates that although the niche combined topic of m-learning and SRL in higher education has attracted attention in several parts of the world, it has been studied in Asia and the United States more than other areas.

Citations.

On average, each article has been cited 15,7 times. However, there was only one article cited 125 times while others were cited under 50 times. In fact, 75% of the articles have had fewer than 15 citations (see Figure 3). The limited and disproportionate number of citations could be due to the current paucity of research in the subject. The most cited article reports a study into the experience of university students learning with English virtual reality (VR) game-based mobile learning application [31]. The study indicated that the quality of *immersion* in VR mobile learning environment

and *gamification elements* help reinforce self-regulation of learning, especially by enhancing students' motivation to learn. It was published in the journal of Computers and Education.

Figure 2. The number of articles by country of correspondence affiliation.

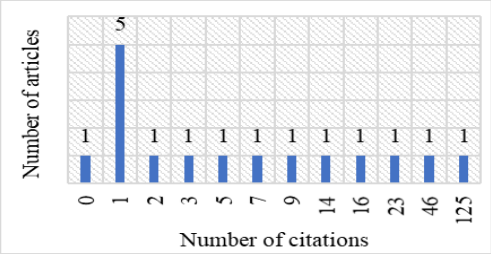

Figure 3. The number of articles with respective citation count.

5.2. Research Topics, Theoretical Frameworks

RQ2: In what subjects/disciplines has the application of mobile learning been studied in higher education?

Most studies either focus on language learning or refer to no specific subject (see Figure 4, labelled "not stated"). The six studies in language learning all refer to English with each study focusing on a different skill, such as vocabulary learning, business writing, or extensive reading. The latter type including six studies surveying university students on their general mobile learning experience. Only a few other studies tried exploring SRL in m-learning for medical, computer science related and technology related subjects.

RQ3: What SRL theoretical frameworks and dimensions have been studied in relation to what types of mobile learning?

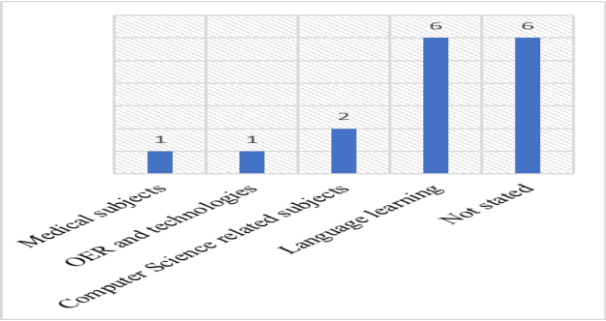

Figure 4. The number of articles by disciplines.

SRL frameworks and dimensions

12 out of 16 studies did not employ a specific theoretical framework for SRL (see Figure 5), more than half of the studies referred to SRL as an integrated skills rather than focusing on a particular SRL strategy such as Time management or Help-seeking. This also accords with the observation of Panadero [18], who noted that some authors usually refer to SRL as an umbrella term to refer to a number of strategies which help learners regulate their learning.

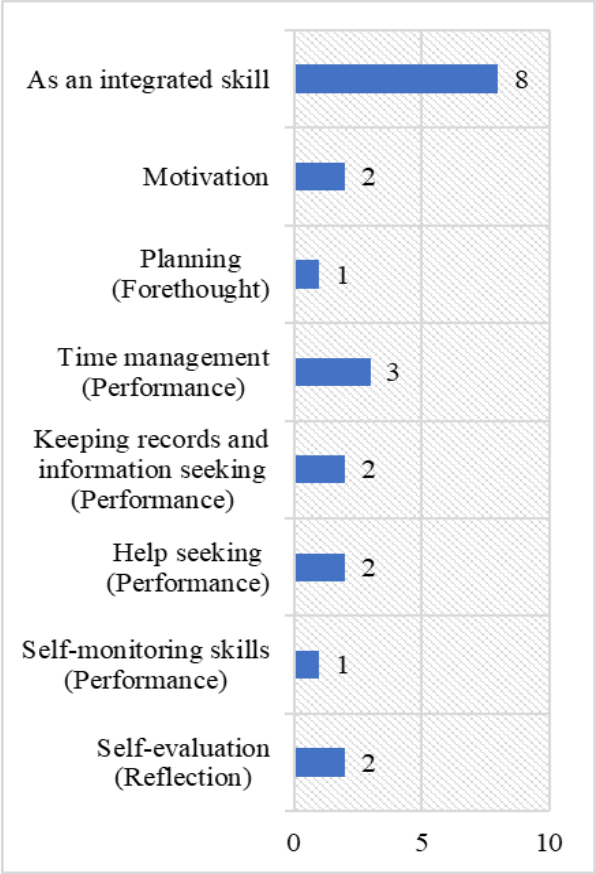

Figure 5. The number of articles by SRL dimensions and skills analysed.

Paring type of mobile learning with SRL skills.

The studies on mobile learning can be categorized into three main types depending on the elements of mobile learning in focus including *mobile electronic devices*, *mobile learning applications*, and *mobile learning interventions*. In the reviewed sample, 6 articles or 37.5% of the studies focus on electronic devices for accessing resources and another 36,5% on mobile-friendly applications, while 25% explore mobile learning interventions. The interventions include providing weekly learning analytics to students [17], sending weekly reflection amplifiers [32], analysing log data to recommend resources [33], and developing apps to help students find mentors [34].

When mobile learning is viewed as the general use of portable devices to access online resources (in studies coded with "electronic devices") (see Table 2), SRL is assessed either as an integrated skill or across various skills in all three phases. In studies that focus on mobile learning as a specific application or intervention, SRL is evaluated more narrowly on one or two

skills. For instance, Tabuenca et al., (2022) [32] targeted time-management using reflection amplifiers ; or Tan et al., (2023) [34] explored help-seeking through a mentor-finding app. These focused approaches are particularly beneficial during transitions, such as moving from high school to university [32] or in situations with limited social connections, like during COVID-19 [34].

Table 2. The number of articles by type of mobile learning and SRL skills

Type of mobile learning paired with SRL skills	**No. of articles**
1. Electronic devices	**6**
As an integrated skill	1
As an integrated skill, Motivation	1
Help seeking (Performance)	1
Keeping records and seeking information (Performance)	1
Planning (Forethought), Task strategies and Time management (Performance), Self-evaluation (Reflection)	1
Time management and self-monitoring skills (Performance)	1
2. Learning application-Created-for-mobile	**6**
As an integrated skill	4
Motivation	1
Self-evaluation (Reflection), Motivation	1
3. Intervention	**4**
Providing LA - As an integrated skill	1
Providing LA - As an integrated skill, Motivation	1
Providing application to find mentor - Help seeking (Performance)	1
Providing reflection amplifiers - Time management (Performance)	1

RQ4: What are the purposes of the studies?

The two main purposes of the studies are to evaluate impact of mobile learning and to explore related factors (see Table 3), and research has focused on impact valuation with 13 out of 16 studies.

In fact, studies with different purposes can complement each other. For instance, impact evaluation studies can identify emerging SRL skills or phases in mobile learning, which exploration studies can then detail, offering tailored recommendations for researchers and practitioners. Conversely, exploration studies can uncover behaviour patterns in mobile learning platforms, informing the design of environments or interventions to enhance SRL skills and learning performance.

Table 3. The number of articles by purpose of study

Purpose of study	**Number of articles**
1. Impact evaluation	13
To evaluate the impact of learning intervention	4
To evaluate the impact of mobile learning (in general)	3
To evaluate the impact of mobile learning applications	6
2. Exploration of factors	3
To identify learning behaviour	1
To identify perception	2

RQ5: What methodologies have been employed to study SRL in mobile learning environment?

13 studies used a quantitative methodology with questionnaires or computing of log data (see Figure 6). Seven of these studies used a previously established and validated questionnaires, four of which use the Motivated Strategies for Learning Questionnaire [35]. Two other studies employed a mixed method to follow up questionnaires with a focus group [36], or with a reflective journal and interviews [37]. Only two studies use qualitative method with interview to explore the perceived opportunities and challenges in self-regulated learning in mobile learning [5, 35].

We have answered the proposed research questions. Although some insights were drawn from the 16 publications reviewed, it is evident that while the adoption and encouragement of mobile learning in higher education are becoming increasingly widespread, there is still limited focus on self-regulated learning within mobile environments. The relatively low volume of research publications on this topic indicates that the convergence of mobile learning and self-regulated learning has not yet garnered significant attention from the academic community.

This oversight is concerning, given the critical importance of self-regulated learning in fostering student autonomy, enhancing motivation, and improving overall learning outcomes. The lack of focused research in this area could limit the potential of mobile learning to effectively support and develop learners' self-regulation skills. Therefore, more in-depth and comprehensive research is needed to explore how mobile learning can be optimized to support self-regulated learning, thereby maximizing the benefits that mobile learning can provide to learners.

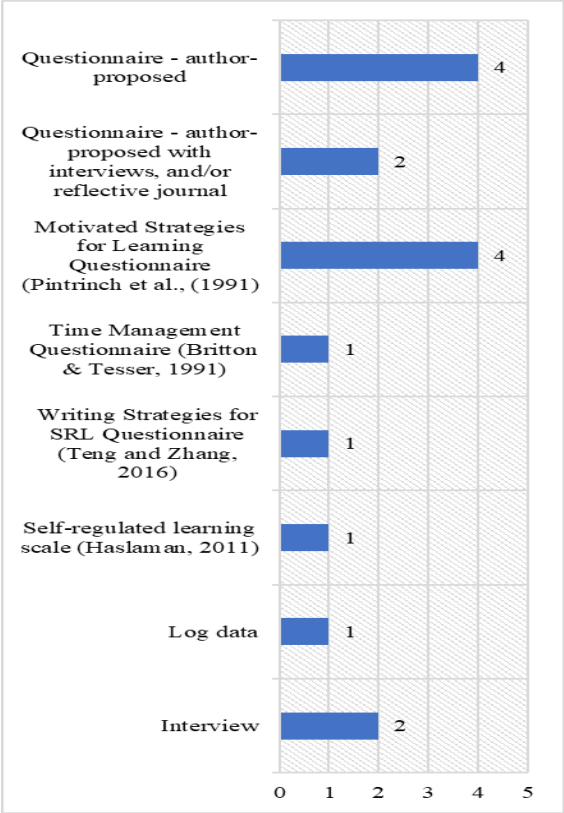

Figure 6. The number of articles by research methodologies.

6. Discussion and Conclusion

This study explores self-regulated learning (SRL) in mobile learning environments for higher education, an area that has gained interest recently, particularly due to the rise of mobile learning during COVID-19. The complexity of higher education subjects and the time and resources needed to develop mobile learning tools have slowed progress in this field.

Despite the limited number of articles reviewed, the study underscores the importance of developing a unified theoretical framework for SRL in mobile learning. The most researched SRL phase is Performance, covering time management and self-monitoring, with some attention to Reflection. Furthermore, although "Motivation" is studied across different types of mobile learning, the results are mixed. Chen and Hsu (2020) [31], Misdi et al., (2023) [37], and Eom (2021) [38] reported enhanced motivation in their studies on mobile learning applications and electronic devices. However, Cavus Ezin and Yilmaz (2023) [17] found no significant difference between experimental and control groups. Variability in findings on motivation could be due to differences in mobile learning designs, student populations, and study methodologies. The novelty effect-where students initially find mobile learning engaging but lose interest over time-might also explain why some studies report positive motivation effects while others do not. Altogether, this highlights the need for further research into student motivation on mobile learning platforms.

Most research has focused on using mobile learning for language learning and interventions like reflection prompts, with fewer studies on other subjects or comprehensive mobile courses. This is possibly due to mobile learning being compatible with text-based and interactive exercises. In contrast, STEM subjects often require complex visualizations, simulations, and problem-solving tasks, which are more challenging to implement effectively on mobile platforms. There is a need for research on how students use mobile learning for other subjects, like STEM, which require different cognitive skills.

The literature largely examines how mobile learning affects SRL, self-efficacy, and motivation, and how these factors impact learning performance. This corroborates the earlier observations of Yıldız et al., (2020) [39] that the most researched topics of mobile learning during the period 2011-2015 were to evaluate effectiveness of mobile learning usages and to design a system. So far, there has been limited exploration of mobile learning interventions, such as prompts or help-seeking apps, and few studies have detailed learners' SRL behaviours in mobile contexts. Future research could benefit from examining these aspects, especially as students increasingly use mobile tools and apps that support SRL.

The study also suggests that future research should investigate pedagogy in mobile learning to support SRL. While current studies focus on learners, content, and environment, more work is needed on theoretical frameworks and guidelines to help educators manage learning in mobile environments. This is particularly relevant as teachers navigate the new role as consultants instead of being "experts" as in traditional settings [21]. By doing so, researchers can contribute to the development of robust theoretical frameworks and practical strategies that not only enhance the effectiveness of mobile learning but also foster lifelong learning skills. This continued research effort will be crucial in driving innovation in educational practices, ensuring that mobile learning fulfils its promise of providing accessible, effective, and inclusive education for all.

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