

RESEARCH ARTICLE

A Survey on Mobile Learning for Adult Learners: State-of-the-Art, Taxonomy, and Challenges

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This work was supported in part by the Kolej Universiti Poly-Tech MARA (KUPTM) for KUPTM Internal Research Grant under Grant URG/0520/FCOM/FP01318 (10).

ABSTRACT Adult learner performance has become a significant challenge in education. Adult learners are identified as being of productive age in engaging with multiple commitments, including studying. The multiple engagements make managing their time and focus difficult, contributing to a high institutional dropout rate. This situation has reduced the number of highly skilled and professional workers in the country because of the failure to meet academic requirements. In the current digital world, every aspect of education includes some technology elements. However, most adult learners are reluctant to utilize mobile technology for learning. Therefore, this review paper aims to provide state of the art on mobile learning (m-Learning) for adult learners. Considering a set of inclusion and exclusion criteria, 135 related articles from IEEE, Google Scholar, Springer Link, Science Direct, Taylor and Francis, and Wiley digital databases were extracted and reviewed. State of the art were discussed in terms of functions of m-Learning, effectiveness, and m-Learning as a tool. Keywords from articles were extracted and the taxonomy of m-Learning was discussed under five classifications (behavioural intention, technological support, educational content, learner coordination, and instructional design), representing the same meaning and features discussed in the articles. The findings can raise awareness among mobile learning practitioners to provide more effective services for adult learners. Meanwhile, higher education institutions can be better redesigned in terms of pedagogy to fit the needs of adult learners with mobile learning.

INDEX TERMS m-Learning, adult learner, andragogy, acceptance, intention.

I. INTRODUCTION

Today, technologies provide various benefits to make life better. To facilitate managing human life, the use of mobile technology is helpful for educational purposes. Thus, the application of mobile technology eventually extends from everyday communication to becoming a meaningful learning environment known as m-Learning. M-Learning activities are made possible by reconstructing learning intentions through interactive presentations and knowledge exchange. Rapid

expansion has led education and information technology companies to provide many m-Learning products. However, m-Learning currently focuses on secondary and primary education rather than tertiary [1]. There are limited considerations towards higher education learners when most possess adult characteristics [2]. Adult learners can be defined as those individuals as adolescents advancing to adulthood and their involvement in adult learning processes and education [3]. Consideration towards them should not be compromised because they have a variety of commitments, especially after enrolling as a student later in life.

According to the ASEAN Statistical Yearbook [4], the working age in the Association of Southeast Asian Nations

The associate editor coordinating the review of this manuscript and approving it for publication was Jon Atli Benediktsson^{id}.

begins at 15, and the number of working adults increases yearly. In Malaysia, according to statistics of working people from Statistik Tenaga Buruh [5], the number significantly increased (0.1%) compared to July 2016 (14,212.8). Despite this, adults are considered the most productive age that leads to economic growth.

In the context of adult learners, data is drawn from enrolment statistics in Malaysia. Based on the Malaysia Youth Databank System, the number of Malaysian enrolled learners between the ages of 19 and 30 shows the most. Table 1 illustrates the distribution of enrolled learners according to age.

TABLE 1. Statistics of Citizen Students in public universities in Malaysia by age for the year 2019-2021.

Category	Age	Total	Number of Youth 2, 474,287
Youth	>18 years & above	246,369	
	19-24 Years	1,783,882	
	25-30 Years	260,155	
	31-40 Years	183,881	
Not youth	>41 years & above	57,080	

Last update: 23 March 2022
[6]

Source: Malaysia Youth Data Bank System

The statistics indicate the same age range of working people and graduate learners. This is because this age range is the most productive age for working, and also when learners have the highest motivation to study and gain certification.

Today, even though adult learners are digital natives, conventional learning styles are still predominantly preferred. Unlike younger learners, using print materials is more convenient for adult learners because it allows them to highlight points, read quickly, or take notes for further explanation [7]. Therefore, adult learners limit themselves in the use of m-Learning applications by denying its advantages. The use of smartphone equipment and services in conjunction with m-Learning activities is explicitly stated by the applications. The coincidental approach to m-Learning for adult learners was found to be dependent solely on this m-Learning support and trustworthy sharing platform [8]. Commitments to many domestic responsibilities and a lack of time management skills result in adult learners refusing to explore m-Learning technology further. This leads to a decline in participation in learning processes, which later causes them to fail in completing tasks. Unfortunately, when these opportunities are overlooked, adult learners often cease their studies, causing a high dropout rate in educational institutions [9]. This also causes a reduction of highly skilled and knowledge-

able professional adults. Indirectly, the country's economy is challenged by this high dropout rate. This is because of the need to hire professionals from outside, the waste of fees for learning materials, and fewer contributions from local professionals to sustain the economy. There have been many review studies conducted in the context of mobile learning. For example, a survey on the mobile learning tools for applied sciences was done by [10]. The data shows that due to their familiarity with mobile devices, students are more likely to employ m-Learning during teaching and learning activities. The psychological elements of motivation and self-efficacy are the most frequently investigated variables to ascertain the efficacy of mobile learning, according to a study by [11]. This study's goal is to comprehend how m-Learning is now being utilised, which will help to assure its effective deployment [12]. The research reveals eight context factors, including the learner's cognitive state, time, learning style, place, technology, and people. These conclusions are meant to help practitioners make sure the material being delivered is appropriate.

However, there is a lack of knowledge on mobile learning for adult learners. There isn't much research about the aspects of mobile learning to which one should pay attention before starting to design an application. To improve m-Learning applications and add valuable features for users, it can be helpful to understand the components of m-Learning. Additionally, research from the past indicates that digital content is given more weight than the need to build m-Learning [13]. This is because a well-built mobile application architecture for learning purposes can enhance teaching and learning activities by taking into account learners' intentions, environmental factors, technology, and learning design [13].

Therefore, this paper aims to review and classify the latest literature on m-Learning for adult learners. The main objectives of this paper are as follows: (i) to discuss the challenges of m-Learning for adult learners, (ii) to examine the state-of-the-art of m-Learning, and (iii) to present the taxonomy of m-Learning

This paper's essential contribution is to raise awareness among m-Learning practitioners before they begin to create, develop, or use it during a learning session. It defines the characteristics that must be considered so that higher education institutions (HEI) can formulate a clear plan before investing in and implementing any m-Learning application/platform. Furthermore, HEI can be redesigned in terms of pedagogy to fit the needs of adult learners with m-Learning. This appears to be a must, and it should be a component of m-Learning practitioners created for HEI learners. As a result, this study can make m-Learning more accessible for adult learners. Despite the fact that there are numerous m-learning applications on the market today, HEIs must still carefully select which m-Learning features best match the demands of adult learners. This study emphasizes the impact of m-Learning on adults to rethink the mobile learning packages they offer and acquire the infrastructure required to complete their tasks in the digital era. Simultaneously, m-Learning may broaden

the geographic and temporal scope of the prospective learning environment, resulting in a shift in study habits [14]. To enable m-Learning acceptance in the presence of an adult learner context, it is vital that the principle of adult learning be considered. This principle reveals the main element of adult learner behaviour in terms of intentions and activities, but with one goal; to propose a better learning a taxonomy for the classification of m-Learning elements. The remainder of this paper is organised into seven sections. Section 2 presents the adult learner's concept, Section 3 presents the adult learner challenges, Section 4 presents the m-Learning concept, Section 5 presents the methodology, Section 6 outlines the state-of-the-arts and Section 7 Taxonomy of m-Learning.

II. LITERATURE REVIEW

A. ADULT LEARNER DOMAIN DEFINITION

This section explores the definition of adult learners adopted in various studies. The definition of adult learners is first presented, followed by exploring the various contexts of adult learners from prior studies.

Adult learners can be defined as those individuals as adolescents advancing to adulthood and their involvement in adult learning processes and education [3]. The Harvard Centre defines Gen X as those born between 1965 and 1984 and aged between 35 and 53 years, representing the common age of adults. Previous researchers agree that HEI learners aged 18-24 years are known as young adults. In the Malaysian context, HEI is a platform that provides formal and informal academic activities mostly to enrol learners aged 18 years old and above to be awarded a certificate in recognition of their skills and knowledge [15]. Typically, those aged between 24 – 50 years are known as mature adults [16], while those above the age of 50 are known as older adults [17]. This is consistent with the studies conducted by [18] and [19], who suggested that the age range for adults is between 22 to 58 years. However, in Malaysia, the qualifying age for enrolment as a part-time learner in a public HEI is around 21 years or above. Also, given that the retirement age in Malaysia is 56 years, adult learners are typically classified as adults between 21 and 55 who are enrolled in any institution with a structured education programme.

Thus, this gives the impression that they are adults who have gained much in life, have vast working experience, and are returning to universities and other educational institutions to enrol and participate in academic programmes [20]. They pursue their education for many reasons, such as to learn new skills, fulfil workplace demands, become better-informed employees, and simply for the sake of gaining more knowledge [16].

In some cases, adult learners are seeking qualifications in recognising their skills and used as a stepping stone in their life achievements and positions at work. Moreover, the intention is to enhance and define skills throughout a life-long learning process. All learning processes are typically achieved from past and present life experiences, which

TABLE 2. Adult learner contexts.

Source	Adult learner context study
[26]	Public service personnel and private company employees.
[25]	Capstone design students, a course often structured to simulate professional work experience.
[24]	Formal, non-formal and informal learning 16–64-year-old adults' proficiency in key information-processing skills in technology-rich environments (TRE)
[7]	Enhance the reading experience of adult learners by incorporating Augmented Reality (AR) technology.
[14]	Postgraduate students in multiple discipline
[27]	68 undergraduates from various study fields who were undertaking English language courses in Malaysia university
[28]	Undergraduate and postgraduate degrees from a university in the United States (US).
[22]	Paediatric trainees in medical education.
[29]	Adults aged 60-75 participating in life-long education.
[30]	European adult learners in a formal education system.

are intended to improve learners' awareness, understanding, competencies, and decision-making abilities which can be applied in personal, social, and employment contexts [21].

Furthermore, adults tend to integrate their learnings with their social activities to produce a consequential learning environment [22]. In other words, to retain success and quality of life, adults must place themselves in an active position of learning, known as 'andragogy'. It is also claimed that this approach is the point at which individuals achieve a degree of self-concept and self-direction as adults [23]. This is in accordance with emphasising life-long skills in adult learning and education [3].

Table 2 below depicts the context of adult learners from previous studies, in which most adult learners are engaged in formal learning programmes. Only those studies by [24] and [25] have focused on part-time learners. Linked with multiple commitments and age factors, all of these contexts are present in the andragogy theory.

However, limited opportunities to gain sufficient study time can lead to a preference for m-Learning. Although "lack of" commitment does not often reflect their experience and instead mirrors the standards in traditional classrooms [31]. With regards to having a high expectation of learning, adult learners wish to be taught things that will be useful and expect an immediate result by seeking courses that are relevant and not wasteful. An organised approach may encourage adults to identify and explore their needs and preparedness to learn. Institutions can help them achieve this aspect by strategizing

m-Learning, enabling them to learn at their own pace and convenience.

B. ADULT LEARNING THEORY

This section discusses the adult learning theory proposed by [32], namely andragogy, in which four principles are reviewed that characterise adult learner behaviour. These principles are chosen since they are fundamental in determining behaviour.

1) ANDRAGOGY

The andragogy theory is presented in this section. First developed by [32], it defines the practices of teaching adults and has been proven to be a helpful learning approach that promotes m-Learning [33], [34].

Being removed from the formal classroom environment for a certain time, the pedagogical approach has become quite irrelevant, especially when applied to teaching and learning since it presents a series of problems [35], [36]. One of the problems concerns the difference between pedagogical and andragogic approaches, moving from teacher-oriented to student-oriented, respectively [24]. Adult learner experiences result in taking action, especially when the content is seen to be relevant to their livelihood. Thus, they require assistance to help them manage commitments; otherwise, they will fail, which will later disrupt the learning of others. In eliciting a better understanding, this study focuses on the four principles of adult learners adopted from the work of Knowles.

2) ADULT LEARNING PRINCIPLES

Adult learners tend to learn more independently from their own experiences. This self-directed learning experience is known as 'andragogy'. Andragogy is defined as the art and science of helping adults to learn [30;33]. The process and rationale of self-directed learning facilitate the application of appropriate, well-planned, and effective teaching and learning [24]. [38] believed that instructors must pay attention to the actual interests of learners instead of focusing on what they, as instructors, believe to be important.

Consequently, the assumptions presented by [32] surrounding the four principles, namely Self-direction (SD), Prior Experience (PrEx), Learning Readiness (LR) and Orientation to Learning (OL), were not solely derived from past research. Adult learners are uniquely different when it comes to the effects of learning [39]. Therefore, it is important to produce coherent and reliable accounts of the proliferation of m-Learning in the setting of adult learners, given their limitations and constraints. For instance, most m-Learning applications do not suit the relationship between the learning objectives and the attributes of adult learners regarding their learning management and preferences.

Nevertheless, the majority of the studies found in the literature focused mainly on determining the methods and approaches concerning the content and technical presentation [1]. Even though the study of 'acceptance' has been tested and evaluated in many situations, it still needs to be refined

owing to different technologies (including m-Learning) and the need for different approaches within different contexts or environments [40].

3) ADULT LEARNERS' LEARNING PLATFORM

Nowadays, even though adult learners are recognised as digital natives, conventional learning styles are still predominantly preferred. Unlike younger learners, using printed materials is more convenient for adult learners since it enables them to highlight points, read quickly, or take notes for further explanation [7]. As such, adult learners tend to limit themselves in the application of m-Learning by denying its advantages. Likewise, commitments to domestic and work responsibilities and limited time management skills result in adult learners refusing to explore m-Learning technology. This leads to a diminishing decline in their participation in the learning process, which later causes them to fail to complete learning tasks. Unfortunately, when these opportunities are overlooked, adult learners often cease continuing their studies resulting in a high dropout rate in HEIs (Youde & Youde, 2018). This also causes a reduction in highly skilled and knowledgeable professional adult workers. Indirectly, the economy also faces a challenge and is impacted by this high dropout rate due to the need to hire professionals from outside the organisation, waste of fees for learning materials, and fewer contributions from local professionals to sustain the economy.

III. ADULT LEARNER CHALLENGES

In this section, the challenges faced by adult learners are presented, which include time, content, and collaboration. The cause is also elaborated for each challenge, based on the considerations of adult learners.

Time becomes a challenge among adult learners due to multiple responsibilities and commitments. Thus, time management skills are needed to manage learning activities and prioritise personal responsibilities and commitments [24]. However, one of the challenges associated with time is constrained by formal classroom schedules. Adult learners need to entertain various commitments such as career, family, and study that prevent them from attending a physical class [16]. When revising their schedule to incorporate social obligations, learners need to combine the pressures of in-depth or intense study and find the time to spend with their family. Once ways to improve time management have been identified, they can begin to adjust their day-to-day routines and behavioural patterns to reduce any time-related stress in their lives.

In terms of *learning content*, previous learning technologies such as e-learning and digital learning should reshape the focus on mobile or mobility discussions and solutions by improving availability, accessibility, sharing of subject material, and providing real-time feedback [43]. However, it is equally important to identify the needs of mobile applications that suit or are compatible with adult learners by reducing the

TABLE 3. Adult learner challenges.

	Time	Content	Collaboration
Challenges	Adult learners need some flexibility during learning processes given they have commitments and multiple responsibilities [21]	Not many studies have considered adult learners' needs and behaviour [28], [35]	Learners need concern by practitioners to explore the model's suitability for them with completing demands which require flexibility of study [20]
Cause	Some online learning functions did not emphasise suitable activities that could trigger learner participation [41]. The needs of education for new learners are different and the andragogical model is highly considered [40]	Techno-assisted solutions for adult illiterate are not available in the first place [1] when most m-Learning applications are developed for formal undergraduates and children	Adult learners do not utilise mobile technology in their learning [42]. Lack of adequate competencies required for participating in m-Learning activities [18]

level of complexity; otherwise, it may discourage them from using the application.

Next, collaboration provides a suitable alternative for advanced teaching and learning solutions. This is interpreted as the accessibility of the course, communication within the system, constant contact, accessibility of tasks, tests, and completion of exams. However, not all adult learners are technology literate and struggle with applying technology, although this depends on the learner's readiness. For example, they do not perceive m-Learning technology as complex and challenging; if this is not the case, it might discourage learners from using such systems [28]. As a result, this will influence their cognitive ability to receive academic content, given their preconceived needs and demands present a problem with their limited cognitive capacities [44].

However, the literature fails to demonstrate appropriate studies to solve cognitive load issues such as time, commitment, and requirements among adult learners, especially from the aspect of instructional design. Learning can only be effectively adopted when the learners can identify and understand their needs and practice perfecting their skills.

IV. UNDERSTANDING OF THE M-LEARNING CONCEPT

This section presents the concept and m-Learning fundamentals. Numerous studies regarding the concept and definition of m-Learning processes have been reviewed, in which the concept is divided into three mobility types: technology, learner, and learning. The three forms of mobility are defined as a means of explaining the importance of their role, in addition to the learner and learning activities being

mediated by modern mobile technology, using wireless internet connections.

Technology Mobility refers to any mobile device used to acquire knowledge without time or place restrictions. With the assistance and support of modern infrastructures such as cloud computing, storage technology, networks, and big data, further mobility access can be gained first-hand, thus expanding the concept by using a variety of learning activities. [45] and [46] highlighted the limitations of using m-Learning technology (such as device battery life, screen, data entry methods, network connectivity, memory, and bandwidth) concerning the mobility of technology. This can be addressed by matching only the related functions of m-Learning that fit the needs of adult learners to reduce physical and wastage of mobile devices. The use of mobile technology in education can be exploited by integrating the strengths of mobile technology with the curriculum.

Learner mobility refers to the ability to access and attain benefits from the learning process, irrespective of time and place. It is typically perceived that adult learners have difficulty attending classrooms in person. Factors contributing to this include factors such as not being geographically located nor viable for travelling and family and work commitments, which create barriers to accessing learning.

Learning is a process of cooperation, harmonisation, and cross-border information exchanges in education. Today, the retention rate for learner mobility has become a new challenge in Higher Education Institutions and teaching culture. Therefore, adult learners must adapt to learning how to utilise technology rather than simply using it to communicate and gather information. Applying theory to this cause is proposed to integrate adult learner participation and learning performance, which will result in better achievements in learning outcomes.

A. M-LEARNING CURRENT USAGE AND FEATURES OUTLINE

In this section, the current use and m-Learning features are presented. The word "usage" in this context refers to the continued use m-Learning after initial adoption. [47]. Nowadays, many m-Learning applications developed by software vendors are offered to users, including technology companies, academics, practitioners, educators, and learners. As such, this provides learners with many choices depending on their requirements. Some applications provide one-way communication, such as for citation and word processing. In contrast, other applications offer two-way communication, such as used for social networking (i.e., WhatsApp, Facebook, etc.), Google classroom and Learning Management Systems (LMS).

To improve the performance of m-Learning, many features have been suggested by researchers, as indicated in Table 4 below. Most researchers suggest having a collaborative medium, followed by a searching function. As mobile devices are beneficial to adult learners in acquiring knowledge and collaboration [48], they also offer opportunities

TABLE 4. Suggested features of m-Learning.

Suggested Features	Sources
Layout navigation that accompanies key information, instructions and feedback	[50]
Searches, expression, communication, create records and give and receive feedback.	[51]
The tool must be easy to use, reliable, short enough, and able to use as more than a general guideline.	[52]
Acting as a remote control, displaying and analysing information, interfacing to social networks to monitor “things” that can be tweeted or posted for learning activities and tasks informally.	[53]
Tracked and recorded to deliver insightful information on learner’s mobile learning progress	[54]
Search window, group history, search suggestions, web annotation tool, auto-summary, and discussion room/forum.	[55]
Implementation of mobile-assisted language learning	[27]
Searching, sharing, and organising.	[56]
Easy to use and valuable to allows them to acquire, apply, and protect their knowledge efficiently	[57]
Blogs, forums, and chat rooms	[55]

during m-Learning activities to empower the learners by developing their self-sufficiency [49].

V. METHODOLOGY

The analysis in the domain under study involved two steps: (a) collection of related publications and (b) analysis of these articles. In the first step, a keyword-based search was performed on papers published in major journals and conferences. The electronic database sources used in this study included: IEEE, Google Scholar, Springer Link, Science Direct, Taylor and Francis, and Wiley. The following search strings in different combinations were used: mobile learning, adult learners, higher education institutions, educational settings, mobile technologies, smartphones, iPads, tablets, and working students. In our selection process, we were guided by the following inclusion criteria:

- Papers published during 2018 – 2021.
- Papers published in peer-reviewed journals.
- Papers published in English.
- Papers in which titles, abstracts, and/or keywords included the following words and phrases in different

combinations: mobile learning, adult learners, mobile devices, formal learning contexts, higher education institutions, and education.

The following query has been used as keywords:

[“mobile learning” OR “m-learning”] AND [“adult learner” OR “higher education”]

Initially, 325 articles on the emergence of m-Learning were collected and reviewed. Papers were filtered out by considering inclusion and exclusion metrics. The papers which covered m-Learning for adult learners, published from 2016 to 2021, published in English language and full length have been considered. Additionally Finally, 135 articles remained to be considered in this study. The final papers were analyzed one by one to answer the following research questions.

1. What is the state of the art of m-Learning?
2. What is the taxonomy of m-Learning elements?

The state of the art of m-Learning were discussed in terms of functions of m-Learning, effectiveness, and m-Learning as a tool. For the taxonomy of m-Learning, keywords from articles were extracted and listed. Then, five classifications (Behavioural Intention, Technological Support, Educational Content, Learner Coordination, and Instructional Design) were created based on these keywords, representing the same meaning and features discussed in the articles. The discussion of the findings related to the research questions are presented in Sections VI and VII, respectively.

VI. STATE-OF-THE-ART OF M-LEARNING

This section of the study examines state-of-the-art m-Learning that provides advantages to adult learners through using mobile devices specifically to respond to a variety of m-Learning activities. For adult learners to engage with m-Learning activities, this section focuses on conducting a detailed analysis of the role and impact of m-Learning among adult learners. The main contribution of this study is to explore the strengths of m-Learning for supporting the decision-makers of regional institutions in designing the required m-Learning infrastructure that connects with adult learners

A. FUNCTIONS OF M-LEARNING

The function of m-Learning in providing a better solution for the learners is covered in this section. Mobile technology companies openly compete to offer sophisticated features, functionality and services to mobile users. Even though they aim to provide an effective and reliable mobile environment, this section discusses the features that can be utilised in the learning environment, which include collaborative functions, searching skills, and organising learning activities.

Since m-Learning offers an interactive virtual learning environment, it also refers to what is called the ‘flipped’ classroom [58], formal and informal learning [59], and hybrid learning [60]. It also resides in the same category since m-Learning offers a learning opportunity from different

contexts of learning among people and technologies. Moreover, it is fast becoming a solution for achieving interactive m-Learning among adult learners, facilitating the mastering of collaborative working skills, and achieving learning outcomes [8], [61].

Nevertheless, there are many opportunities offered by m-Learning technologies, such as learning collaborative skills [62], [63], searching skills [51], [55], and organising learning activities [62], [64], [65]. However, these skills rely on learner preferences, given that adult learners tend to work in groups or individually. If adult learners prefer to work in a group, collaborative and social interaction skills are helpful because they present an opportunity that may suit group work, such as enabling synchronised interactions, posting, sharing with group members, and allowing immediate feedback. Compared to an individual learning style, the preference is more towards searching and 'blogging' (a form of communication) since this offers asynchronous communication and self-efficacy.

To support adult learners to learn more effectively, m-Learning applications must offer many optional functions. As self-directed people, adult learners tend to manage their learning process independently. Therefore, establishing and offering adult learner requirements is helpful for task management while at the same time offering a better learning platform with transparent experiences [51].

B. EFFECTIVENESS

The effectiveness of m-Learning is presented in this section which helps adult learners to learn optimally. This flexibility may help the adult learner address and overcome learning barriers by allowing them to use m-Learning at any time and anywhere consistently [52]. Likewise, having the advantage of owning a mobile device, adult learners can acquire or gain a good understanding of mobile technology, which means that they are accessible and contactable 24/7 and able to respond promptly [66]. Mobile technology provides broader access (no geographic boundaries), is cheaper, easy to use, and has excellent data processing capabilities. As demonstrated by [67] in his analysis, technology has a moderate effect on learning effectiveness. This is because it has become the quickest tool to change the way humans think and act [42]. Despite this, the content and delivery processes should be reviewed appropriately to avoid learner mismatch [68].

Furthermore, by offering knowledge and engaging information, this efficacy may assist comprehensive and integrated answers to numerous social, economic, and obstacles among adult learners [69]. Therefore, this suggests that m-Learning can outperform other platforms as a flexible tool, given it is fast and informative. Also, effective use of this technology as a tool suits learning by attracting active participation from learners.

Regarding this degree of flexibility, it surpasses the application of e-learning in terms of its economic viability, convenience, and ability to achieve the practice of lifelong learning [71]. As such, these opportunities, in combination, build a

good rapport. In achieving meaningful learning effectiveness, prior studies have articulated that integrating technology and pedagogy, it becomes a potent learning tool; also, by offering sound, if not reasonable, interaction time, the gaps between educators and learners can be reduced [70] and hence lead to higher learning effectiveness.

However, empirical studies on m-Learning in adult learner settings are limited and non-transformative in nature because technology has predominantly dominated the learning approach [41]. This is because many attributes influence the effectiveness of the learning experience. For example, [67] outlines some of the perspectives on effectiveness that include the domain subject, application types, intervention duration, and learning environment.

C. M-LEARNING AS A TOOL

Recent studies establish m-Learning as one of the proposed tools that can be employed in this domain [49] since it offers flexibility in use and is proven to have the ability to improve learner efficiency. However, if learners fail to explore its uniqueness, they will invariably fail to achieve the objective, thus increasing the dropout rate in HEIs. Tools that can be used for m-Learning purposes include smartphones, personal digital assistants (PDAs), mobile phones, tablets and the internet (for universal connection).

Notwithstanding, m-Learning tools mediate the learner's learning goals by providing specific software tools that can be used to develop software applications. The opportunity to access learning tools anytime and anywhere has increased significantly over the years. In addition, m-Learning tools help in gaining the confidence of learners by designing applications that are both effective and easy to use. Implementing m-Learning tools during the learning process could also improve learners' academic performance [71].

Since m-Learning can be utilised on any mobile device, computer and digital literacy are needed to avoid learning barriers [65], [72]; otherwise, it is difficult to achieve the desired learning outcomes because the benefits of m-Learning are compromised. Conversely, if adult learners fail to master m-Learning tools and functions, the teacher or lecturer may have good reason to worry about the bewilderment of learners to take advantage of m-Learning [73]. Therefore, it is important to ensure that the layout of interactive tools is intuitive and engaging. This will help facilitate the learners' take-up in adopting m-Learning, and attract a large user-base that can increase knowledge sharing, peer-learning, and collaboration [71].

VII. TAXONOMY OF MOBILE LEARNING

This section presents the taxonomy of m-Learning, including the features, and evaluation that focuses on the critical elements based on specific directions for this research. Figure 1 illustrates the thematic taxonomy of m-Learning. As a first step in the design of the theoretical framework, the taxonomy of the element of m-Learning in an adult learning environment was defined based on the identified keywords.

This taxonomy formed the foundation of the m-Learning acceptance framework, which would include the relevant adult learner's characteristics.

To develop this taxonomy, keywords from articles on the emergence of m-Learning were collected and listed. Then, five classifications (behavioural intention, technological support, educational content, learner coordination, and instructional design) were created based on the thematic approach, representing the same meaning and features discussed in the articles. The element of m-Learning was classified into five categories as in Figure 1. Table 5 also presents the sources of m-Learning elements and sub-elements.

The *Behavioural intention* parameter reflects the adult learner's plan to use m-Learning based on certain behaviours, namely, acceptance, learning style, and intention to use [54], [57], [69], [74]–[76]. *Technology support* signifies the scope of mobile device services in which m-Learning operates and functions, including multimedia support, native applications, and adaptive learning [77]–[79]. *Educational content* signifies the availability of educational material that allows for the gathering and exploration of data by learners [45]. *Learner coordination* determines the approach to organising different elements of the learning materials to make them useful, including autonomous learning, meta-learning, and the social environment dimensions [18]. Lastly, *Instructional Design* explains how to prepare a meaningful learning environment by involving interactive m-Learning, managing the volume of knowledge to be delivered, and applying teaching and learning strategies [20].

A. BEHAVIOURAL INTENTION

Behavioural intention reflects the possibilities of using m-Learning based on certain behaviour. In contrast, acceptance can be defined as exploring user behavioural patterns at the adoption stage and the continual use of technology [80]. Since acceptance can be described as an individual act based on personalisation, it is essential to identify learning styles to enable the benefits afforded by using the tools to be optimised, thereby reducing any form of loss and wastage.

On the other hand, the intention is the individual's decision on what to use and whether to accept m-Learning as a learning tool [49]. Moreover, intention can be used to measure adult learner acceptance of m-Learning. Therefore, the focus placed on acceptance models is important in order to develop and propose attributes that influence the intention to use m-Learning in line with its innovativeness and the needs of mobile learners [81], unless the operation and execution of effective m-Learning are disrupted, effective implementation cannot be achieved [76].

Figure 2 illustrates the m-Learning by adult learners. In the first column, learning behaviour refers to the effort and persistence of adult learners in carrying out their learning activities, categorised as SD, PrEx, LR, and orientation to learning. The definition column expands on each aspect, while the features column indicates behavior characteristics.

The activities column proposes tasks that may be carried out according to adult learner behaviour.

Therefore, it is important, if not necessary, to understand the needs of participants to ensure the system can efficiently obtain knowledge [54]. By understanding the patterns of usage, it may help to identify which activities are suitable for integration during the learning process.

B. TECHNOLOGY SUPPORT

Modern infrastructure using cloud-based mobile technologies has significantly contributed to the rapid growth of m-Learning applications. As such, weaknesses in the classroom environment (i.e., classroom sessions) can be addressed by satisfying the requirements of adult learners [86] and helping learners to understand information through interactive media and production.

This interactive production assists in delivering various multimedia formats reflecting high-quality, quick, and cost-effective presentations via multiple sources, discussion, and collaboration [82]. Significantly, the association between words and pictures can increase one's memory in learning since audio-visual material is easier to retain. This is because people learn more by using all of their senses. However, [7] mentioned that there is a challenge in maintaining a balance between the entertainment aspect of learning and the educational content of learning information. [80] suggest that the optimum length for multimedia presentations should be between two and five minutes, given audio-visual material is much easier to learn and remember.

Native applications are software applications stored inside mobile devices and are system specific. For example, any form of social media is supported by having its application, such as Facebook, according to the program developed [89]. More than half of the m-Learning tools constitute native applications [80], which need to be downloaded from various online platforms and installed on the device. Some applications are free, while others need to be purchased. However, the advantages of mobile hardware and personalisation through downloading and installing these native applications can be compromised [53]. According to these findings, it is, therefore important to revise the singular native theory that emphasises native model efficiency [66].

Adaptive learning can be described as an exercise where mobile devices are used as a medium in the learning environment by considering human needs and can be organised and adapted to different learners having different learning backgrounds and disciplines [83]. Particularly in the case of adult learners, using adaptive learning is the best way to help manage their busy lifestyle and learning [39]. Also, by having the capacity to undertake many learning types and methods, it extends the learning features of the device, allowing for broader communication amongst learners.

C. EDUCATIONAL CONTENT

This section presents the practices and guidance for learners, also enabling educators to design their teaching materials

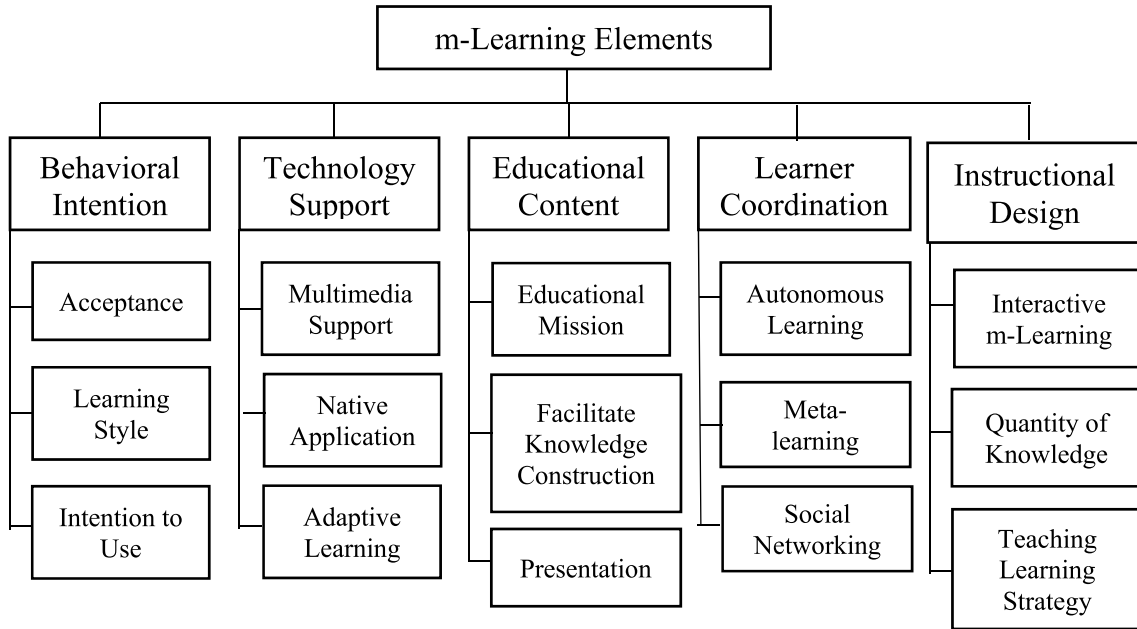


FIGURE 1. Thematic taxonomy of m-Learning.

TABLE 5. Mobile learning taxonomy.

Taxonomy elements	Sub-element	References
Behavioral Intention	Acceptance	[80]
	Learning Style	[81]
	Intention to Use	[49]
Technology Support	Multimedia Support	[82].
	Native Application	[80]
	Adaptive Learning	[83]
Educational Content	Educational Mission	[45]
	Facilitate Knowledge Construction	[52]
	Presentation	[83]
Learner Coordination	Autonomous Learning	[72]
	Meta-learning	[84], [85].
	Social Networking	[86] [18]
Instructional Design	Interactive m-Learning	[8]
	Quantity of Knowledge	[46] [87]
	Teaching Learning Strategy	[1], [21], [88].

more effectively. Three tools are suggested to assist adult learners in acquiring information in a variety of ways such as i) adding shortcuts to the web browser for quicker searching, ii) accessing mail servers for collaboration and sharing of information, and iii) adding contact addresses for easy access to colleagues [45].

Additionally, educators can assist adult learners in completing their educational mission and intentions by utilising content through inquiring, integrating, constructing, and applying it to actual exercises and scenarios [24], [45]. Thus, the capability for repetitive learning content is needed to

maximise learning competencies [52]. Likewise, facilitating knowledge construction can be managed by doing, saying, writing, presenting, and producing. However, this should be undertaken repeatedly to obtain a clear idea of the objectives and to help with memory retention. In terms of presentation, m-Learning can be viewed as extending the structure of e-learning, using less text but supported by certain functions such as videos, pictures, and documents during the transfer of knowledge.

Therefore, many methods in delivering content can be used, including textual, images, animation and speech.

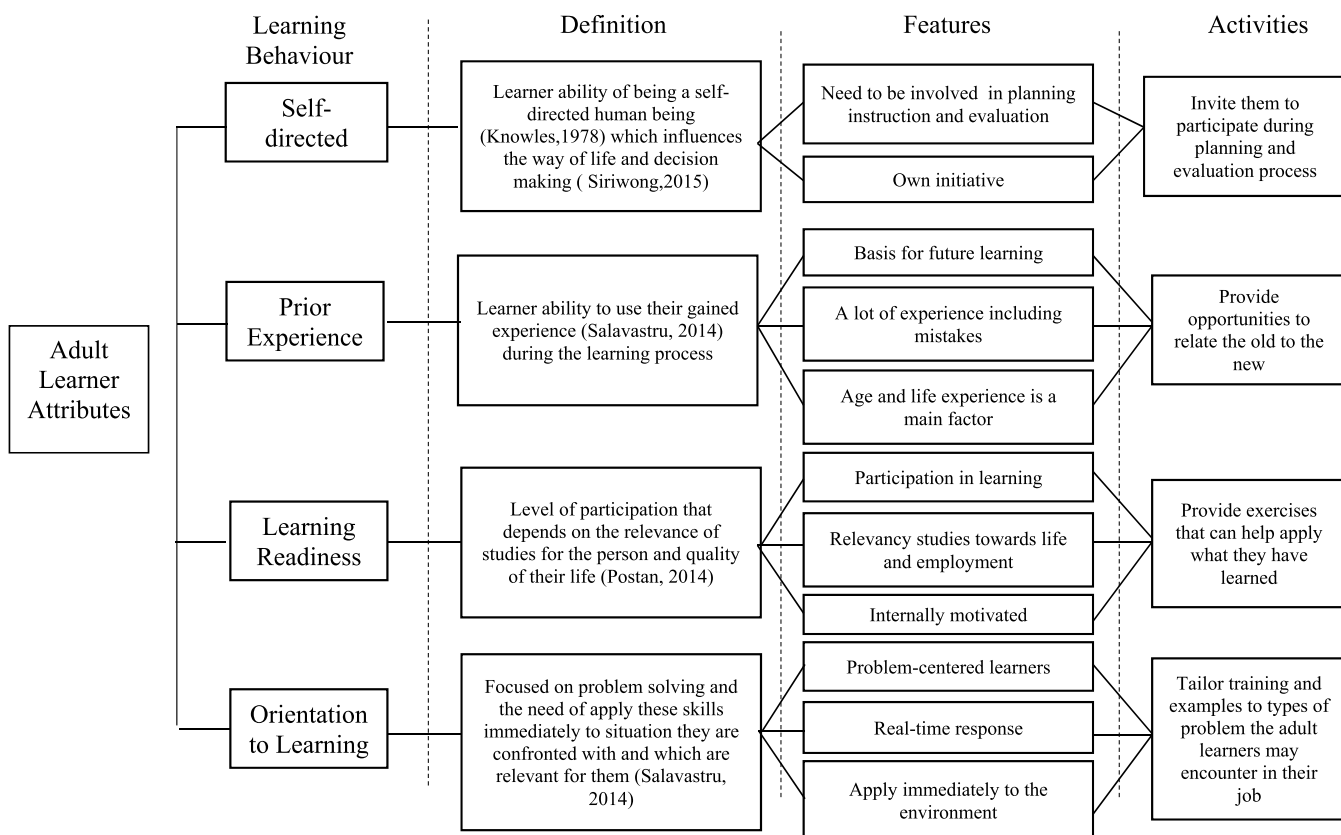


FIGURE 2. m-Learning by adult learners.

Importantly, nowadays, mobile literacy and accessibility are catered for in software applications, specifically developed to retrieve information in a short time. If this is not achieved, the content will become obsolete due to awkward input methods [50].

D. LEARNER COORDINATION

Learner coordination refers to the centredness of adult learners and those directly involved in managing their learning experience. This approach is an ongoing (life-long learning process) synchronous with adult learning [90]. Here, adult learners have the authority and the added responsibility for any accomplishments and results resulting from their actions to improve their learning ability. In line with autonomous learning, the aim is to allow learners to have complete responsibility for their learning process.

Indirectly, this practice supports their aptitude or skills, which is Self-directed (SD), upon which time constructivism develops when learners begin to explore and build their knowledge. To maintain active participation, learners must also sustain their discipline and increase their skills in self-management [91]. For instance, SD and autonomous learning become a principal concept of humanity that consummates the theory of andragogy [72]. *Meta-learning* refers to the consciousness of adult learners towards their learning process and the way it should be managed [84], [85]. This

consciousness is closely related to how they understand their learning motives and how to control and deploy it towards the selected approach.

Nevertheless, significant relationships between personal factors, situational contexts, approaches to learning, and the quality of outcomes have significantly influenced the concept of meta-learning [84]. The capability of learners (to become the mediator) demonstrates that this correlation has resulted in their model of learning. Moreover, identifying introspective activities triggered by learner reflections could enhance the level of motivation and acquired knowledge [85]. As such, learners remain engaged and enthused as the activities have allowed them to express their views.

However, combining the use of mobile devices and the meta-learning platform is required to allow adult learners to be actively involved in activities through the proper channels [85]. *Social network* refers to interactions with peers with similar interests through mobile devices, which has become a widespread phenomenon amongst researchers because it has evolved and become an important component in m-Learning applications [86]. Further, it can support collaborative learning to ensure any negotiations and interactions are effectively utilised, rather than merely focusing on performance. In line with a study by [18], the majority of higher degree holders are involved in many social networking groups. However, they refuse to participate in m-Learning activities, causing them to lose interest in their contribution.

E. INSTRUCTIONAL DESIGN

Instructional design is the practice of preparing a valuable learning experience by a professional. The learning experience is designed according to specific knowledge acquisition, skills, and interactions requirements using suitable learning theory [92]. Here, the determination of learning goals and suitable activities is affected by the fast growth of the web 2.0 host and therefore, needs to be well suited to m-Learning. The section presents a discussion on interactive m-Learning, the quality of education and teaching and learning strategy.

Interactive m-Learning provides effective communication for adult learners concerning SD and informal learning experiences [39]. Here, the instructional design provides the methods of ensuring the learners remain engaged [18] by using multiple options of learning styles, such as audio, visual, and any interactive means [8], [93]. Institutions can support interactive m-Learning through diverse access to educational involvement by implementing this learning style through the aid of m-Learning technology.

Likewise, the quality of education can be evaluated by several dimensions: information, systems, and services [86]. Studies have shown that lessons delivered simultaneously may lead to cognitive overload [46], while the over-delivery text could distract the learning process by reducing lesson content and focus [87]. Accordingly, only related and useful information can be employed during learning sessions. Hence, personalised content can help adult learners to engage during the learning process actively with a small amount of knowledge [94].

Teaching and learning strategies have also presented opportunities to adult learners seeking information in various ways regarding their preferences and learning styles. These can be used efficiently for some activities such as question and answer sessions, cooperation, game-based learning, decision-making, and problem-solving in specific learning situations [1], [21], [88].

VIII. CONCLUSION AND FINAL REMARKS

In this study, adult learners and m-Learning issues were discussed in detail. This section discusses the acceptance of m-Learning among adult learners, which can be viewed as a branch of behavioural intention to accept m-Learning. The literature review examined state-of-the-art m-Learning practices, in which a thematic taxonomy of m-Learning was developed. In turn, there is a lack of consideration about the aspect of adult learners as well as the attributes of adult learners in HEIs in Malaysia in defining acceptance as a part of m-Learning. The comparative analysis is undertaken of state-of-the-art m-Learning solutions, including the use of m-Learning, in light of the proposed thematic taxonomy.

The state-of-the-art aids in highlighting the present elements of m-Learning that may contribute to a better adult learning environment. Every mobile vendor and manufacturer compete to design and develop a complex feature. The camera and real-time communication have recently become the advantage features influencing user intent [93]. Furthermore, this small and portable device may aid the learner by

giving huge storage space for storing a great amount of data in one location.

Regarding effectiveness, m-Learning can be a valuable learning tool because it allows learners to study while on the go. When thoroughly offered information and platform are available at all times and places, the internet integration can be used. Information may be retrieved in real-time, and a large amount of data is available. The behavioural intentions that impact adult learners in order to obtain acceptance of m-Learning via empirical analysis are identified as research topics and challenges in the field of m-Learning [54].

As a result, the taxonomy that divides m-Learning into five sections (Behavioral Intention, Technology Support, Educational Content, Learner Coordination, Instructional Design) may provide some insight into what should be considered during m-Learning implementation for adults learners in HEI. In addition to BI, it demonstrates the majority of what has been discussed in prior studies. When BI stated and formed the learner's learning style, it represented the adult learner's critical part. It is necessary to first evaluate their intentions before beginning to design, develop, and execute m-Learning. As a result, determining adult learner BI becomes critical to guaranteeing the successful implementation of m-Learning that uncovers the next section of the suggested taxonomy. It also aids in reducing the likelihood of failure in fulfilling adult learners' learning objectives and using m-Learning.

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