Learning on the Move: A Pedagogical Framework for State-of-the-Art Mobile Learning

Ashraf Alam and Atasi Mohanty

Abstract Efforts in both technology and pedagogy concentrate on four central axes that together define the educational landscape of the future. Mobility, interactivity, artificial intelligence, technological learning tools like games, and augmented reality all fall under this category. Combining them requires creating a mobile-interactive model that takes into consideration the learner's availability and their convenient times. Technology is already being utilized in education, albeit various forms of it are used in different settings. Because of this, it is critical to integrate and combine them into pedagogical models that place a premium on the students' education. This article analyzes many kinds of technology and proposes a unified model that might serve as a basis for classroom education. In the end, it is emphasized how important it is to have intelligent tutoring systems in order to make tutoring broadly available, as well as how important it is to conduct technological experiments and apply the findings to 'teaching–learning models' that make use of multiple interaction patterns.

Keywords Social networks · AI · Mobile learning · Pedagogy · Curriculum · Teaching · Learning · Educational technology · Smart campuses

1 1 Mobile Learning Platform

Today, information and knowledge can be accessed in record time, technological advances are being made at a faster rate than pedagogical ones, and the future of many academic disciplines is determined by technological advances [1]. The Horizon Report forecasted that mobile computing will increase in popularity over the next several years based on evidence of device sales [2]. Two elements that have helped the rise of mobile learning are the expansion of mobile access plans and the introduction of mobile learning that is accessible to all students [3]. The widespread use of Internet access via mobile devices is working to level the playing field for people of different races and socioeconomic backgrounds [4].

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As a result of mobile devices' versatility and the ease with which they may be combined with other technologies, have had a profound effect on the education sector. They make it possible to have resources available at any time, and from any place, creating a convergence of opportunities that, if harnessed properly, might improve educational performance [5]. The concept of mobility, when applied to the field of education, has the potential to make processes universal and to combine formal classroom learning with informal learning in social networks, thereby shattering structures and concepts and paving the way for several innovations whose effects can only be fully appreciated through personal experience [6].

The Web 2.0 phenomenon has helped extend the mobile wave internationally, in addition to its use in the classroom [7]. People spend a lot of time on the Internet for fun and games, so it makes sense that they spend a lot of time uploading content to share with others, chatting with each other, and working together to produce knowledge as part of a larger group [8].

The responsibilities of a student may be divided and simplified into four categories using mobile learning:

1. Producing and recording one's own music is a skill that may be taught to students.
2. There are resources available to help students learn.
3. Inputs to the learning process are digitally processed by the students.
4. Via their interactions with one another and their instructors, students form relationships that are conducive to their academic growth.

The fourth category focuses on the dialog that develops between professors and their students within a network of education [9]. Through interpersonal interactions and social learning, a social constructivist environment is produced in which the social context serves as the basis for the creation of knowledge, and constructive community behaviors are encouraged [10].

Mobile devices broaden our access to information and facilitate interaction, learning, and group work. It improves the dynamism of education by increasing the available means of communication [11]. Nonetheless, it is critical to develop experimental models that include cutting-edge innovation, since they may lead to beneficial educational results [12]. Practitioners and theorists in this area have advocated for more research to be conducted on the efficacy of using mobile devices in the classroom, with positive results widely documented [13]. While research and anecdotal evidence from many mobile learning domains are available, this information must be synthesized and included in reference models that accurately depict the desired results in terms of usefulness and effectiveness [14]. There is a distinction between egocentric and object-centric social networks, but otherwise, conversations in these structures are mostly focused on the topics and information being shared [9].

2 Learning and Socialization

Experience-based learning, or 'informal education', refers to instruction that is based on actual life circumstances [15]. Every day, via trial and error, chance meetings, and unexpected circumstances, we expand our prospects and horizons of possibilities [16]. Often it is believed to be unusual for learning to take place in an informal setting. Informal learning originated in the social learning theory, which states that individuals are more likely to adopt desirable behaviors from others around them [17] (Table 1).

With randomly occurring content-generating visuals and moving pictures, users can think critically and creatively while completing complicated tasks when they are presented with information in several formats (text, audio, music, images, pictures, animation, and video). Talking about problems, it stems from people wanting to hear other people's perspectives or educate themselves on how others in their community feel about various topics [18, 19].

The explosive popularity of mobile phones has sparked the creation of related technologies with an emphasis on improving society [20, 21]. Students may engage in a group-based, inclusive spiral by producing, sharing, commenting on, and enhancing the content using Web 2.0 technologies and social networks [22]. In addition, courtesy mobile technology, these pursuits may be engaged anytime, anywhere [23]. One of the main advantages of mobile technology is that it makes it easier for people to communicate with one another. These days, users like to have asynchronous conversations rather than ones that occur at set intervals [24]. With this, learning becomes a way of life rather than a routine activity. Formal subjects may be learned in an informal setting via the usage of social networks [25]. Students produce material, communicate with one another, and acquire knowledge on curriculum-related topics [26]. It is evident that today's youth have made informal learning a normal part of their lives. Academia must adapt to these new conditions, to which students are accustomed and has become comfortable to, in order to take advantage of the spaces that social networks provide and, more crucially, the strategies employed to connect and learn jointly [27].

3 AI and Recommender Systems

AI has recently expanded into the field of recommender systems (RSs), which provide personalized recommendations for content, actions, and products [28]. An RS may provide a product suggestion or a product prediction depending on the user's preferences [29]. RSs may be seen as an information filtering system that offers customized product suggestions to the user [30]. These provide a convenient way to suggest relevant people, places, and things to others. The future of artificial intelligence will be in RSs. They act as tutors and provide assistance to teachers in the classroom to

Table 1 Trends in mobile learning

1	Flash to HTML5	HTML5 has become the smarter and faster way to render engaging content such as animations and videos to a whole range of mobile devices
2	Mobile app analytics	In 2025, we can expect to see analytics playing a bigger role in understanding learners' interaction and behavior with mobile-based courses, such as by monitoring app traffic and visualizing page-flows
3	Responsive Web development for multi-device consistency	There is a greater shift toward keeping content responsive, i.e., adjustable to different screen sizes to provide consistency in the quality of learning experiences because of the multi-screen usage trend
4	Mobiles as devices for competency-based learning	There is an escalating trend of mobile videos and simulators being used for professional competency building, such as in the healthcare and manufacturing industries
5	Geo-location sensitive learning	Learning design that is based on a social, mobile, real-time lemming, and geo location can create authentic, personalized, and context-aware learning models wherein learners can have real-time dashboards to monitor their progress and access to the right content or experts based on geolocation
6	Social mobile learning	Brainstorming discussions, events, and groups on Facebook or a specially created social mobile platform are rapidly changing how employees interact with each other to share knowledge and drive innovation
7	Device agnostic design approach	The rise of the BYOD trend calls for a design approach that can cater to a variety of devices at the workplace and device agnostic content is the answer to it
8	Multi-screen usage	A GfK study confirmed in 2014 that shuffling between multiple screens has become a norm. The same is true for mobile learning as both smartphones and tablets have become an inseparable part of our lives
9	Byte-sized learning for performance support	Mobiles are being injected as the ultimate medium for just-in-time support which could come in easily digestible and immediately useful information 'nuggets'

(continued)

Table 1 (continued)

10	Gamified learning and assistance	Gamification on the mobile is fun, engaging, and convenient and provides an easy method to teach abstract concepts such as team building and decision making
11	Augmented reality for mobiles	Mobile apps that superimpose digital information on a mobile or tablet screen that captures an object using the camera have already been developed
12	Wearable devices	Be it for monitoring health, finding directions, or connecting with people, there is a lot of activity in the wearable technology segment. As wearables shift from becoming more of a need than a luxury, we can expect them to see them being used actively for learning

propose educational materials and activities [31]. Because of their immense potential, they are expected to play a pivotal role in the evolution of massive open online courses (MOOCs) [32]. RSs are an integral part of the academic process in a variety of studies. Intelligent technologies can help users find the digital learning resources that best suit their individual profiles [33]. Interface agents, semantic refining agents, user profile agents, search engine agents, mediator agents, and recommender agents are all parts of the multi-agent architecture used in the creation of intelligent systems. In addition, we have the continuous improvement of e-learning courses framework (CIECoF), a collaborative RS for education whose main aim is to help professors improve their online lessons [34]. This is accomplished by applying distributed data mining to a client–server architecture with N clients all using the same association rule mining technique locally on their own and taking as input the prior behavior of students in an online course.

By analyzing student participation in OpenACS/dotLRN course forums, unsupervised learning approaches in VLEs are facilitating the creation of recommendations that improve students' educational experiences. These studies are only a small sample of the substantial literature on the topic of incorporating AI into instructional materials and practices.

4 Augmented Reality

The term 'augmented reality' (AR) is used to describe a world that goes beyond the capabilities of the human senses. Augmented reality is a technology that superimposes digital information over a user's live view of the world. Data created by computers, or data of any kind, might be stored here. Augmented reality is a technology that uses graphics, vision, and multimedia to superimpose digital information onto a user's real-world surroundings. Static, dynamic, interactive, or autonomous

Table 2 Design tips for mobile learning

1	Minimize GUI functionalities	Use minimum functional elements and should be highly visible and large enough to operate easily
2	Divide the course into multiple modules	Short modules capture learners' attention and make them stay focused till the end
3	Offer small nuggets	To have just-in-time knowledge during their downtime to retain only essential information
4	Replace long text with audio	Based on the target audience and their working environment, replace large sections of text with audio
5	Avoid complicated graphics and background images	Complex graphics and backgrounds distract the learners' attention
6	Minimize scrolls	Try to avoid scrolls, if not, use vertical scrolls as the height of a mobile screen is more than its width
7	Design for a single-hand use	Users use their mobile with a single hand and use their thumb to navigate through the screen (the average width of the adult thumb is 25 mm)
8	Use simple interactivities	Use simple interactives such as clicking on tabs, images, icons, rollovers, and hotspots for effective learning

features may all be used in augmented reality applications. These components may be seen on a conventional monitor, a device with enhanced vision, or holographic projections. Allowing students to engage with the real world, where more knowledge is stored, is a major benefit. Adding this layer allows for the modification of reality via the use of digital components, which may enhance learning and the ability to perceive the world around them (Table 2).

In the classroom, augmented reality technology might have a major influence. It is best employed for investigating sensitive or inaccessible fields of information. Augmented reality technology is not a spectator sport. Students may use it to learn new material by engaging with virtual objects that illustrate abstract concepts. Dynamic processes, enormous datasets, and unusually shaped or scaled items may all be brought into the learner's personal space at a level and in a manner that is simple to grasp and deal with. The ability of students to see, hear, and change content gives them an edge over more conventional learning approaches, making interactive and autonomous elements extremely important in the field of education. Also, it is feasible to repeat specific steps of a process as much as needed without squandering resources or putting oneself in harm. The multi-modal visualization of complex theoretical concepts, the practical exploration of the theory through concrete examples, the natural interaction with multimedia representations of teaching material, and the successful collaboration and discussion among the participants are four possible benefits of augmented reality in the field of education.

5 Game-Based Learning

Game-based learning refers to the use and development of game mechanics in 'non-game' contexts. Motive, cognition, and sociocultural lenses may all be used in the study of game-based learning. Students with ambition and access to material that is somewhat inspiring have a chance of succeeding in school. Several studies have shown a correlation between study motivation and retention. There are six factors that combine to create a state of intrinsic motivation: challenge, control, fantasy, competence, cooperation, and acknowledgment. These features promote user engagement, and they align with the shift from a teacher-centered to a learner-centered teaching approach. From a theoretical point of view, there are two avenues for incorporating games into higher education. At the outset, games are used for a wider variety of reasons, and their presence within a set of educational activities is given more importance. That is why they are so useful; they make it possible to expand one's knowledge and skill set. Second, games are used when they add something useful to the content being covered.

6 Incorporating Technology into Classroom Learning

Several studies and standards have been developed because of the incorporation of technology in classrooms. These have facilitated the organization of schoolwork and provided guidelines for the most effective use of technological advances in education. By going through that procedure, it became clear that both teaching techniques and teaching–learning materials affect student learning. This exemplifies the need of taking a holistic view of teaching and learning models, as well as the strong relationship between concepts and approaches. In certain cases, it is important to guide formative behaviors by providing context, which may be aided by a conceptual framework that positions mobile learning from multiple viewpoints. In an early attempt to establish a platform for studying mobile learning, a four-type classification of mobile learning systems was devised [1]. Figure 1 divides the x-axis into two halves, with individualistic pursuits ($-x$) and collaborative pursuits ($+x$). High transactional distance ($-y$) occurs when an endeavor needs a highly structured academic curriculum, whereas low transactional distance ($+y$) occurs when no such structure is seen to be necessary [1].

7 Ubiquitous Learning

The most game-changing inventions are also the ones most likely to be forgotten. The term 'ubiquitous computing' characterizes situations in which computers are present but not intrusive. As this concept is applied to the realm of education, we get

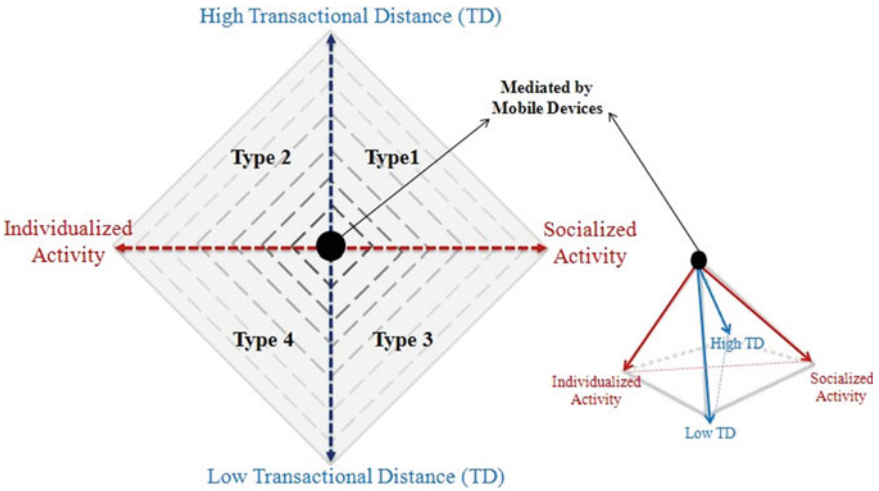

Fig. 1 Mobile learning framework [1]

the term ubiquitous learning (u-learning), which refers to the practice of learning in an environment where all students have constant access to a variety of digital tools and resources, such as mobile computing devices and Internet-connected computers. Figure 2 illustrates the conceptual shifts from e-learning to m-learning to u-learning [1]. Using ubiquitous computing in education, we may visualize a classroom in which teachers maintain concentration on their area of expertise while simultaneously using technology to boost student learning [1, 9]. Mobile computers are a vital component of ubiquitous learning, among the many other technological tools that may be used [1].

Involvement, presence, and adaptability are the three parts of yet another paradigm. These concepts serve as tools for evaluating the efficacy of new approaches to mobile education. Alternatively, the following three elements are also often included: individualization, collaboration, and genuineness. With a focus on education, this model takes a spatial and temporal approach to mobility. Beyond conceptual elements, usability should be considered when designing models. One way to

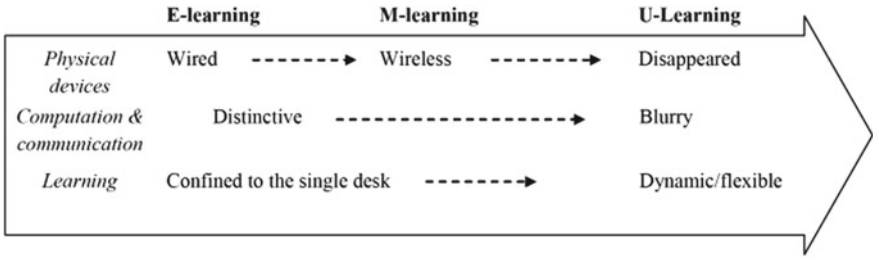

Fig. 2 Flow of e-, m-, and u-learning [1]

achieve this is via the use of a multi-level assessment framework. This may take the form of a model with micro-, meso-, and macro-levels to examine individual behaviors, the learning experience, and the impact on the institution. Two more thorough models exist, however, and they take into consideration mobile devices' core technical components. It involves four parts: incorporating tools, implementing instructional techniques, evaluating evaluation approaches, and training teachers. One is founded on a holistic perspective that allows for optimal context-specific placement of learning. In this paradigm, mobile technology improves the interaction between learners, educators, and teaching–learning materials. Education approaches such as constructivism, active learning, collaborative learning, and blended learning are all applicable here. Essential assessment strategies include, but are not limited to, computer-based assessment, tutor assessment, self-assessment, and peer review (Table 3).

In this article, we provide a framework for defining the elements that, when applied to a digital platform, enable the development of dynamic, intelligent mobile learning scenarios that provide students with an educational experience that is uniquely suited to their needs and preferences. Mobility is the initial pillar of the concept, and its greatest strength is that it allows participants in a teaching–learning process to stay in constant contact with one another regardless of where they are in the world or what time it is. The second aspect of this framework is socialization, the building blocks for an interconnected world. These connections represent the variety and potential of education. The need to combine formal and informal learning is especially important to consider here since informal learning often takes place in social networks via leisure or entertainment content. There are, however, issues with adapting social network technology and methods to the more traditional curriculum used in schools.

8 Visualization of the Connections

Artificial intelligence (AI) plays a supporting role in our method through RSs, which are entrusted with modeling students' learning patterns and customizing tools and resources accordingly, setting our strategy unique from others currently in use. It may act as an online instructor for students. The purpose is to steer pupils in the right direction. Educational resources are often crucial to the learning activities that make up a course's framework. As a result, they boost efficiency and maximize technical potential. Technology like video games and augmented reality may aid students in their learning process. They are interesting because of the multimedia features and easy-to-understand writing. There are two types of interactions between the components, both of which are based on the principle of ubiquity. The first set of connections suggests that learning and practice are key to fostering participation. This is articulated in the course's instructional design, which proposes that formal education evolves into a lifestyle that makes use of informal learning methods and challenges established assumptions.

Table 3 Future of learning

A glimpse into the future of learning	
These changes point the way toward a diverse learning ecosystem in which learning adapts to each child instead of each child trying to adapt to school	Learning will no longer be defined by time and place unless a learner wants to learn at a particular time and in a particular place
	Whatever the path, radical personalization will become the norm, with learning approaches and supports tailored to each learner
	Some of those tools will use rich data to provide insight into learning and suggest strategies for success
	Diverse forms of credentials, certificates, and reputation markers will reflect the many ways in which people learn and demonstrate mastery
	At the same time, geographic and virtual communities will take ownership of learning in new ways, blending it with other kinds of activity
	As more people take it upon themselves to find solutions, a new wave of social innovation will help address resource constraints and other challenges
	Educators' jobs will diversify as many new learning agent roles emerge to support learning
	A wide variety of digital networks, platforms, and content resources will help learners and learning agents connect and learn
	'School' will take many forms. Sometimes, it will be self-organized
	Work will evolve so rapidly that continuous career readiness will become the norm
	Learners and their families will create individualized learning playlists reflecting their particular interests, goals, and values
	Those learning playlists might include public schools but could also include a wide variety of digitally-mediated or place-based learning experiences

The student's interaction with electronic media defines the second group of ties. When a user's actions inside a virtual learning environment (VLE) are tracked, a profile of the user's preferred methods of study may be constructed. There are three elements in any system that influence this connection. The first is input, which originates from the activities of students inside the classroom. In other words, everything from their preferences and actions to the study materials they consult, the activities they partake in, the amount of time they dedicate to them, etc., is tracked (Table 4).

Table 4 Benefits of m-learning over traditional e-learning

Benefits of m-learning over traditional e-learning	
Performance support	M-learning is ideal for performance support intervention as learners have easy access to information while at work. This leads to increased usage and retrieval
Learning path	Mobile devices can be used to update learners on their 'learning path', thereby facilitating 'learning as a continuum'
Higher engagement	The training experience is more immersive, and completion rates are higher as compared to traditional e-learning
Better completion rates and higher retention	The bite-sized or microlearning approach makes it easier for learners to initiate, complete, and retain learning better
Flexibility to learners	With m-learning, learners have the flexibility of learning anytime, anywhere on the device of their choice and in varied formats
Collaborative learning	It is a great way to engage with peers to share learning experiences and be part of communities of specific practices
Multi-device support	The same course is available on varied devices ranging from PCs and laptops to tablets and smartphones

Processing the incoming data is the second stage. Algorithms used in artificial intelligence provide paths to knowledge based on preferences and habits. The materials and activities along these routes are tailored to the learner based on their unique learning profile. By constantly analyzing incoming data, the system is able to grow and learn as it continually refines its predetermined learning paths, patterns, and preferences. The third is the development of online classrooms driven by students' needs and inclinations. This modification is based on the findings from analyzing the students' data.

9 Concluding Remarks

In the not-so-distant future, it is possible that technological aspects may dominate two distinct fields. In the first place, the development of mobile technology has contributed to the widespread acceptance of the concept of ubiquity. For this reason, technological advancements are needed that fully exploit the advantages of mobile learning, adapt methods to new forms of interaction and learning, and develop and experiment with teaching–learning models as alternatives that can raise the students' levels of content assimilation and technological innovation proposals. The second

is that student support and tutoring are increasingly being incorporated into classrooms via automated means. The widespread availability of massive open online courses (MOOCs) is a key factor in propelling the research and development of automated tutoring systems. Artificial intelligence has a lot of potential applications in the classroom, and some of the earliest advances in this direction have already been accomplished. In future, VLEs will have smart features like personalized learning and coaching. In order to successfully deliver adequate learning levels, it is essential to experiment with various technologies and to have a cross-disciplinary methodological axis.

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