



Investigating acceptance toward mobile learning to assist individual knowledge management: Based on activity theory approach

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ABSTRACT

Mobile devices could facilitate human interaction and access to knowledge resources anytime and anywhere. With respect to wide application possibilities of mobile learning, investigating learners' acceptance towards it is an essential issue. Based on activity theory approach, this research explores positive factors for the acceptance of m-learning systems. In the research, we developed an m-learning system for learners' knowledge management and invited 152 participants who knew how to use the m-learning system then report on their experience. The results show that enhancing learners' satisfaction, encouraging learners' autonomy, empowering system functions, and enriching interaction and communication activities have a significant positive influence on the acceptance of m-learning systems.

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1. Introduction

Mobile devices are significantly changing human–computer interaction, communication, and learning activities. Ubiquitous access to remote resources is one of the most interesting characteristics achievable by using mobile or handheld devices, such as Personal Digital Assistants (PDAs) and cellular phones. Computing devices have become commonplace on today's college campuses. From notebook computers to wireless phones and mobile devices, the massive infusion of computing devices and rapidly improved Internet capabilities have the power to altered the nature of higher education. Despite the tremendous growth and potential of the wireless devices and networks, mobile e-learning or mobile learning (m-learning) is still in its infancy and in an embryonic stage (Motiwalla, 2007).

Indeed, m-learning is a relatively new tool in the pedagogical arsenal to support students and teachers as they navigate the options available in the expanding world of distance learning. m-Learning is the learning accomplished with the use of small, portable computing devices. These computing devices may include smart phones, PDAs and similar handheld devices (McConatha & Praul, 2008). Therefore, m-learning intersects mobile computing with e-learning; it combines individualized learning with anytime and anywhere teaching (Quinn, 2001). This type of learning is facilitated by the convergence of the Internet, wireless networks, mobile devices and e-learning systems (Motiwalla, 2007). With a mobile or handheld device, the relationship between the device and its owner becomes one-to-one interaction. Mobile devices have the potential to change the way students behave, the way students interact with each other and their attitude towards learning (Homan & Wood, 2003). The key features of using mobile devices for m-learning are one-to-one interaction place and time independence, capability of personalization, and extended reach. These features have a potential to attract more and more learners, especially adult learners (Motiwalla, 2007). Indeed, the place and time independence of m-learning allows students and instructors to utilize their spare time.

Learning on mobile devices will never fully replace classroom or other electronic learning approaches. However, if leveraged properly, mobile devices can complement and add value to the existing learning styles or models. Mobile devices integrate a series of features and these features have been used in various learning environments. In some mobile learning applications, currently available mobile features have been utilized for various educational practices such as the use of Short Message Service (SMS) for content delivery which did not re-

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quire any additional technical design (Levy & Kennedy, 2005) and the use of sending English vocabulary materials to Japanese students with SMS (Thornton & Houser, 2004). In other approaches, some mobile phone features have been used to create learning environments or add new features for educational purposes, such as a math learning system or a language learning system to help students (Bull & Reid, 2004; Chen, Chang, & Wang, 2008; Chen & Hsu, 2008; Lu, 2008). Moreover, extending e-learning systems with mobile devices for managing learning activities to assist students' learning or instructors' teaching (Chen, Kinshuk, Wei, & Yang, 2008; Ogata, Saito, Paredes, Martin, & Yano, 2008). Regarding various potentially mobile learning applications, it is essential to investigate learners' acceptance towards them.

Teaching and learning processes are concerned with the creation and ongoing development of knowledge and skills within a group of learners. Davenport and Prusak (1998) point out that knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Jennex (2005) defines knowledge management as the process of selectively applying knowledge from previous experiences to current and future decision making activities with the explicit purpose of improving effectiveness. Furthermore, knowledge management is a strategy to be developed as a way to ensure that knowledge reaches the right learner at the right time (O'Dell and Grayson, 1998). From m-learning approach, knowledge management is highly associated with the use of m-learning systems which are extremely beneficial to learners' growth (Chen & Hsiang, 2007). Since knowledge management is regarded as an important part of developing m-learning, finding a way to successfully transform ordinary m-learning to knowledge-based learning will be necessary in order to enhance learning effectiveness and to share the knowledge with others.

A mobile learning theory should embrace the considerable part of learning that occurs outside classrooms and lecture halls as people keep doing their learning activities. Thus, a mobile learning theory must take into account the ubiquitous use of personal and knowledge sharing technology. The activity theory is a cultural–historical activity system and is mediated by tools that both constrain and support learners in their goals of transforming their knowledge and skills. In activity theory, the activity of mobile learning can be separated into two perspectives of tool-mediated activity: (1) semiotic layer and (2) technological layer (Sharples, Taylor, and Vavoula (2005). The semiotic layer describes learning as a semiotic system in which the learner's object-oriented actions are mediated by cultural tools and signs. The learner internalizes public language that was instantiated in writing and conversation, as private thought which then provides the resource for control and development of activity (Vygotsky, 1978). The technological layer represents learning as an engagement with technology in which tools such as computers and mobile devices serve as interactive agents in the process of coming to know, creating a human–technology system to communicate, mediating agreements between learners and aiding recall and reflection (Sharples et al., 2005).

Even though m-learning provides useful applications in education, there is an emerging need for a more applicable framework to provide teachers, educational policy-makers, and researchers with a better representation of educational affordances of m-learning. Based on the activity theory, this research will investigate learners' acceptance towards an m-learning system as a knowledge management tool. First, we will present an m-learning framework that is based on the activity theory. After that, system implementation will be introduced. Next, system evaluation based on users' acceptance will be investigated and in the last section we will discuss our findings and make conclusions.

2. A mobile learning framework based on activity theory

Portraying learning as a mobile activity is not to separate it from other forms of educational activities, since some aspects of learning are fundamentally mobile in the ways outlined above. By placing mobility of learning as the objective of analysis we may understand better how knowledge and learning materials can be transferred across contexts such as homes and schools, how learning can be delivered and managed across life transitions, and how new technologies can be designed to support schools. Indeed, wireless devices have the potential to give instant gratification to students by allowing them to interact with the Internet, access course materials, and retrieve information from anywhere.

Mobile applications generally allow users to control or filter information flow and interaction through the handheld devices. BenMoussa (2003) identified several benefits for mobile connectivity: First, mobile devices offer personalized or individualized connectivity. Second, mobile connectivity improves collaboration via real-time or instant interactivity that may lead to better decision making. And third, mobile connectivity enhances users' orientation or direction. These benefits are proved to be equally useful in improving the learning environment. Besides, Churchill and Churchill (2008) explicated that mobile technology provides five affordances: as a multimedia-access tool, connectivity tool, capture tool, representational tool and analytical tool. Additionally, Churchill and Churchill (2008) also stated that handheld technologies for education have five potential educational benefits: First, portability, as handhelds can be taken to different locations. Second, social interactivity, as handhelds can be used to collaborate with others. Third, context sensitivity, as handhelds can be used to find and gather real or simulated data. Fourth, connectivity, as handhelds enable connection to data collection devices, and to a network. And fifth, individuality, as handhelds can provide scaffolding to the learners' approaches to investigation.

A central concern is that we must understand how people artfully engage with their surrounding environments to create impromptu sites of learning. Sharples (2000) contends that the advances in learning and technology have facilitated setting the stage for a successful mobile learning environment. As learning has become more individualized, learner-centered, situated, collaborative, and ubiquitous, continuing technology has similarly become more personalized, user-centered, mobile, networked, ubiquitous, and durable (Motiwalla, 2007).

From the concept of the activity theory, Engeström analyzes the collective activity through an expanded framework that shows the interactions between tool-mediated activity and the cultural rules, community and division of labor. Rules operating in any context or community refer to the explicit regulations, policies, and conventions that constrain activity as well as the implicit social norms, standards, and relationships among members of the community (Jonassen, 2002). The community consists of the individuals and subgroups that focus at least some of their effort on the object. Division of labor refers to both the horizontal division of tasks between cooperating members of the community and the vertical division of power and status (Engeström, 1999). Sharples et al. (2005) adapted Engeström's framework to show the dialectical relationship between technology and semiotics. They renamed the terms – control, context and communication – that could be adopted either by learning theorists or by technology designers (Fig. 1). In other words, based on the technological approach of the activity theory (such as mobile devices for learning), learning is mediated by knowledge and technology that act as instruments for productive

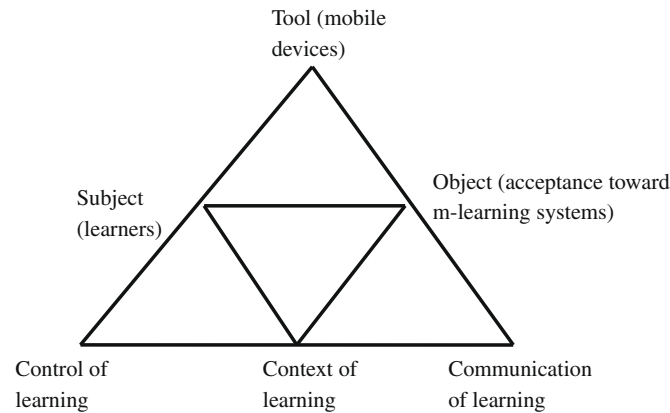


Fig. 1. A framework for analyzing mobile learning based on activity theory.

Table 1

The components based on activity theory and m-learning perspectives.

Component	Activity theory perspective	m-Learning perspective
The control of learning	<ul style="list-style-type: none"> Learners directly access learning materials conveniently Learners control the learning pace and style Learners are independent and competent 	<ul style="list-style-type: none"> Systems provide self-regularity or autonomous learning functions Learners use systems personally and independently
The context of learning	<ul style="list-style-type: none"> Context is an integral property of interaction Context embraces the multiple communities of actors who interact around a shared objective 	<ul style="list-style-type: none"> Systems offer functions for learning activities, such as retrieval content or information, sharing knowledge Systems provide high quality functions to encourage and enhance learners' usage
The communication of learning	<ul style="list-style-type: none"> Learners adapt their communication and learning activities Learners invent new ways of interacting that create new rules and exclusive communities 	<ul style="list-style-type: none"> Systems supply various interaction and communication to support diversely learning activities Systems provide meaningful communication Learners use systems individually or collaboratively

enquiry, in a mutually supportive and dynamically changing relationship. The mediation can be analyzed from a technological perspective of human–computer interaction, physical context and communication activities.

The control of learning may be focused on the teacher usually, or it also may be distributed among the learners. From the activity theory, control rules operate in any context or community refer to the explicit regulations, policies, and conventions that constrain activity as well as the implicit social norms, standards, and relationships among members of the community (Jonassen, 2002). Thus, control may also pass between learners and technology. The technological benefit derives from the way in which learning is delivered such as whether learners can access e-learning materials conveniently, and whether they can control the learning pace and style of interaction. Thus, from the m-learning perspective, the control of learning is based on learners' self-regularity or autonomy.

From a technological perspective of context of learning, there have been some debates about whether context can be isolated and modeled in a computational system, or whether it is an emergent and integral property of interaction. Indeed, context of learning can embrace multiple communities of actors (both people and interactive technology) who interact around a shared objective. In other words, context of learning is an emergent and integral property of interaction. Thus, from the m-learning system perspective, the context of learning is based on the quality of system interactive functions, physical context, or learning content. Basically, the higher quality of system's functions, the more satisfaction learners have.

Regarding *communication of learning*, if a technological system enables certain forms of communication (such as email or online discussion), learners begin to adapt their communication and learning activities accordingly. As learners become familiar with the technology, they invent new ways of interacting by creating new rules and exclusive communities. This appropriation of technology not only leads to new ways of learning and it also sets up a tension with existing technologies and practices. On a broader scale, mobile technology supports interactions and communication, such as file and information retrieving and knowledge sharing.

Moreover, Arievitich (2007) states that the main educational principles originating from activity theory can be outlined as follow: First, students are active learners, not passive recipients of knowledge. Second, students acquire new knowledge within meaningful learning activities. And third, teachers have to provide adequate learning technology or tools for students' learning activities and to frame the mastery of a new activity in a series of interrelated stages leading students to master new knowledge. Arievitich (2007) also argues that to ensure that learned actions are effective, three psychological requirements should be fulfilled during learning: to ensure the action is meaningful and intelligent, to ensure the action is based on operating with cognitive tools, such as signs or symbols, and to ensure the action is independent and competent.

Based on the technology approach of the activity theory (Sharples et al., 2005) which includes the elements of control, context and communication, as well as from Arievitich's (2007) perspective of educational technology on activity theory, in our m-learning research, the control of learning can be viewed as learners' autonomy toward m-learning. The context of learning can be referred as m-learning system functions and satisfaction toward system functions, and the communication of learning can be pointed as interactive and communicative activities of m-learning. The Table 1 presents the three components based on activity theory and m-learning.

3. System implementation

Knowledge resides in the user's actions toward subject context or information. Unlike information, knowledge is embedded in people, and knowledge creation occurs in the process of interaction, especially social interaction. Knowledge management can be interpreted in terms of understanding the relationship of data, indentifying and documenting rules for managing data and assuring that data are accurate and maintain integrity. From techno-centric perspective, knowledge management is to enhance knowledge sharing and creation. The purpose of the system is to build an m-learning system that could assist learners to search knowledge, retrieve knowledge, create their own knowledge, share knowledge, and manage knowledge. In accordance with this purpose, the design principles of the m-learning system are as follows:

- *Simple*: The m-learning system should be simple and work smoothly because handheld devices have a relatively slow central processing unit (CPU) and a small memory compared to desktop or notebook computers.
- *Adaptive*: Since handheld devices are place and time independent that allow students to utilize their spare time, the system should be easy to operate.
- *Individual*: Since handheld devices are personal tools, the learning activities should be meaningful and customized for individual learners.
- *Communicative*: Handheld devices make it easy to communicate with digital contents or other people. Therefore, the handheld system should provide adaptively communicative and collaborative functions.

Essentially, computer-based technologies can exhibit a special property that is often referred to as interactivity. This property is important for a number of functionalities—including, for example, navigating through an electronic knowledge corpus, controlling how knowledge is displayed on a screen, facilitating flexibility and adaptability, and enabling dynamic and responsive interactive human–computer dialogue. From the view of activity theory, learning is a process in which learners actively find and retrieve knowledge as a result of interacting with the learning environments that we create for them. Knowledge acquisition is therefore an interactive process (Barker, 2005).

Thus, an effective knowledge management methodology could be developed in order for m-learning to be a viable knowledge management tool. From Arievitich's (2007) concept, as mentioned above, the learning activities should be meaningful as well as teachers have to provide adequate learning technology for learning activities so that students can easily acquire new knowledge. Furthermore, BenMoussa (2003) also identified three benefits for mobile connectivity. First, mobile devices offer personalized or individualized connectivity. Second, the connectivity of mobile devices provides various resources via interactivity with the Internet that may lead to better decision making. And third, mobile connectivity enhances users' orientation or direction. Thus, in the m-learning system, we propose a five-stage approach to lead learners to master new knowledge: knowledge retrieval, knowledge gathering, knowledge analysis, knowledge construction, and knowledge management.

The goal of knowledge retrieval stage is to establish domain boundaries and help individuals to ensure that attention is concentrated on relevant knowledge that can then be retrieved. Knowledge gathering is the stage in which relevant knowledge can be found. The first two stages of knowledge retrieval and knowledge gathering are performed by users using a mobile device (PDA). The stage of knowledge analysis is based on individual experience and helps an individual to understand what the demanded knowledge is. The results of knowledge analysis are used to produce a model of tasks in terms of task knowledge structure, which represents the knowledge the individuals possess about the tasks they perform (Uden & Brandt, 2001). The stage of knowledge construction is acquired through learning and previous task performances. Finally, the stage of knowledge management is the stage in which individuals share knowledge with others and manage individual knowledge. The m-learning system is to help individual users when they search for knowledge via the Internet. Fig. 2 is the architecture of the m-learning system.

In the m-learning system, we designed a prototype for users to retrieve knowledge through the Internet and to enhance their knowledge construction and knowledge management capability. This system is a system that uses integrated, personalized, shared, and server-based prototypes. Besides, we created five different functions – the keyword function, the URL resource function, the analysis function, the construction function, and the sharing function to assist individuals in creating and managing their own knowledge from Internet resources. The main platform is the Windows server. The system prototype used to test our research ideas was developed on the Windows platform using Visual Basic.NET, MS-SQL server database, and ASPHTTP.

The first two functions (the keyword function and the URL resource function) of the m-learning can be operated by mobile devices and also by laptop computers. It means users can search, retrieve, and collect Internet resources via handheld tools or personal computers only if those devices have Internet connection. After the first two steps, users process knowledge analysis, knowledge construction, and knowledge management by using laptop computers. The m-learning system also integrates a keyword function for the stage of knowledge retrieval. In the keyword function, users retrieve knowledge from Internet portals or search engines. The URL resource function is established for the second stage (knowledge gathering). The analysis function is created for the stage of knowledge analysis. The analysis function includes two major sub-functions: connection and bookmark sub-functions. The connection sub-function is designed to connect Web pages that users are interested in and the bookmark sub-function is to mark the URLs into the database (users believe those URL addresses are all useful knowledge for them). The construction function is to build individual knowledge. The management function is based on the sharing knowledge sub-function. In the sharing knowledge sub-function, users may also post their valuable knowledge resources into the sharing platform.

Fig. 3 illustrates the main screen of the m-learning system. Fig. 4 presents how mobile devices (PDA) retrieve and gather knowledge. For instance, if a user wants to find “Medical Informatics” from this system, he/she inputs “Medical Informatics” as the keyword into the keyword function on his/her mobile device. This is the stage of knowledge retrieval. After that, based on an Internet search, the results will be presented in the URL function which include URLs and titles of Web pages on his/her mobile device. This is the stage of knowledge gathering. These two stages can also be completed by laptop computers. After that, users connect to Web sites and analyze relative medical informatics resources. This is the stage of knowledge analysis. In the knowledge construction stage, the user needs to decide which medical informatics Web pages are useful and then bookmark those pages. In addition, the user has two optional sub-functions to help him/her to

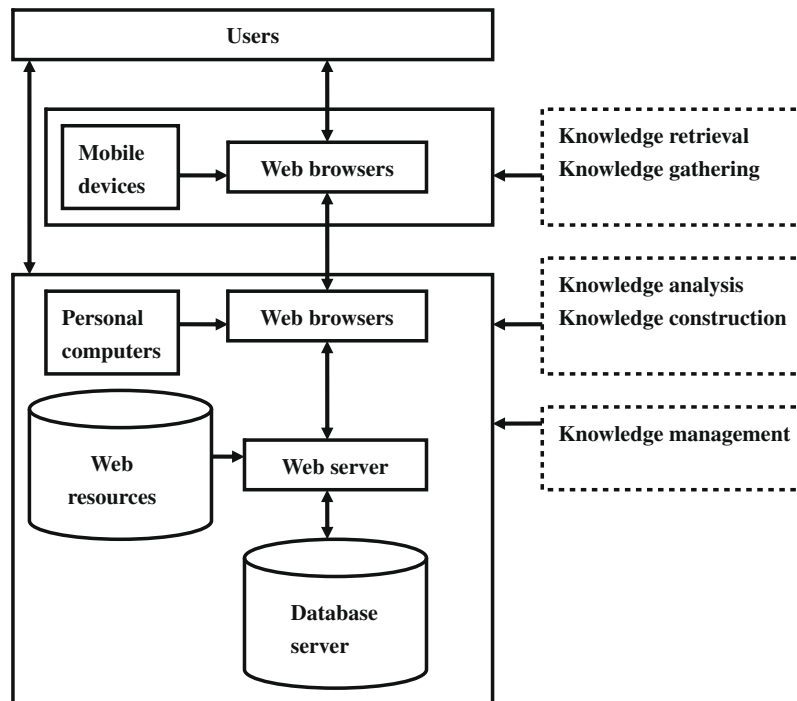


Fig. 2. The architecture of the m-learning system.

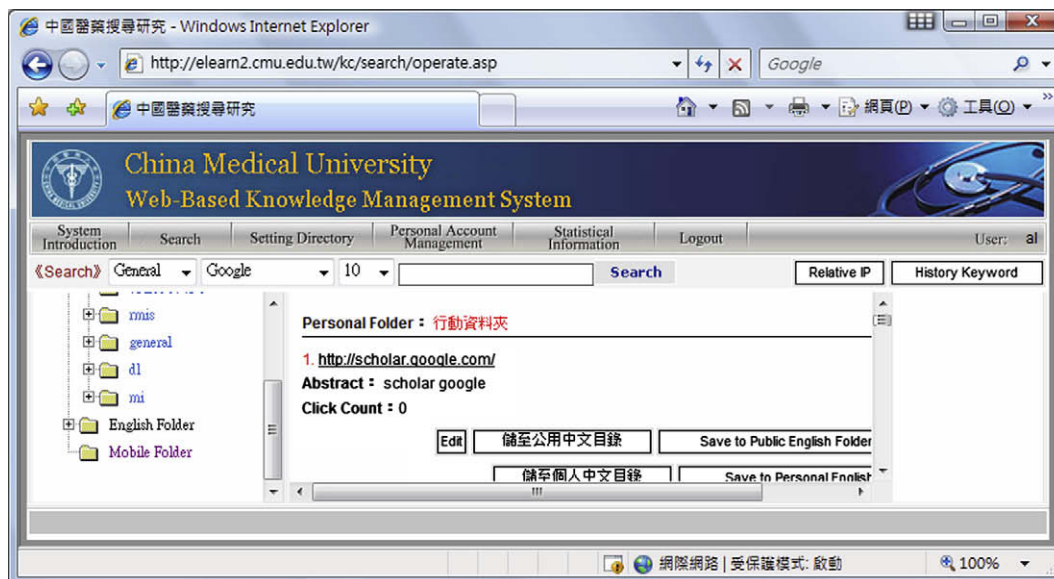


Fig. 3. A mobile directory in the m-learning system.

construct his/her own knowledge. First, he/she can categorize each Web page. And second, the user can input an abstract for each Web page. In the last stage, knowledge sharing, the user may post his/her resources onto the sharing platform.

According to system's functions, the m-learning system supports five affordances for learning.

1. *Support individual learning*: The m-learning system provides learner-centered learning that students can ubiquitously search knowledge or retrieve knowledge anytime and anyplace. In addition, the m-learning system also enhances users' orientation and direction.
2. *Provide seamless interaction activities*: Students can interact with the Internet or each other when they need to no matter whether they are in-class or off-from-class.
3. *Foster collaborative learning*: Any learner can contribute his/her findings to others and also retrieval knowledge from others' findings. The m-learning fosters collaborative learning activities for sharing and managing knowledge. Indeed, the system may improve collaboration via interactivity that may lead to a better decision making.
4. *Reduce time-consuming tasks*: Essentially, learning activities include some frequent, tedious, and redundant tasks. The m-learning system keeps historical blogs for every students and it will reduce their learning time.

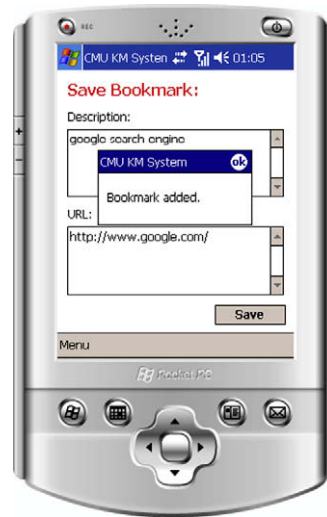


Fig. 4. Knowledge retrieving and gathering by a mobile device.

5. *Create mobile knowledge retrieval and gathering*: When learners have any curiosity about any topic, they just use their PDAs to connect to the Internet and find it. After that, they may construct, share, or manage knowledge of what they find and gather.

4. Research concept

After implementing the m-learning system, the major objective of this study is to explore the level of learners' acceptance towards the system. Essentially, m-learning systems provide opportunities for learners to communicate with the real world and to search interdisciplinary domains via mobile devices. The activity theory provides an alternative lens for analyzing learning processes and outcomes with the context and community that surrounds and supports it (Liaw, Huang, & Chen, 2007). From the activity theory's viewpoint, individuals actively construct their knowledge within social realms; therefore, powerful learning tools, and social interaction are essential for enhancing learning success. In this study, based on the activity theory approach, the four factors (system satisfaction, system activities, learners' autonomy, and system functions) are investigated whether they have positive influence on system acceptance of m-learning or not. In this research, the factor of learners' autonomy means users are autonomous learners when they utilize the m-learning system. Additionally, the factor of system satisfaction infers that users are satisfied with functions of the m-learning system and the factor of system functions indicates the major functions of the m-learning system. Furthermore, the factor of systems activities means that the m-learning system provides various interactive and communicative methodologies for learning activities.

The research concept is shown in Fig. 5. Fig. 5 presents the three major components: the activity theory, m-learning system implementation, and investigating learners' acceptance. In the Fig. 5, the relationship between the activity theory and m-learning is based on Table 1. Additionally, these two components have predictive relationships on learners' acceptance toward m-learning. Fig. 6 presents learners' acceptance toward m-learning systems as a knowledge management tool that is based on activity theory perspective.

5. System evaluation based on users' acceptance

In this research, 152 participants (51 men and 101 women), who had used the m-learning system for knowledge management, answered a questionnaire survey. The questionnaire included two major parts; one was attitudes toward mobile device operating skills; another one was attitudes toward the m-learning system. All questions were scored on a 7-point Likert scale (ranging from 1 which means

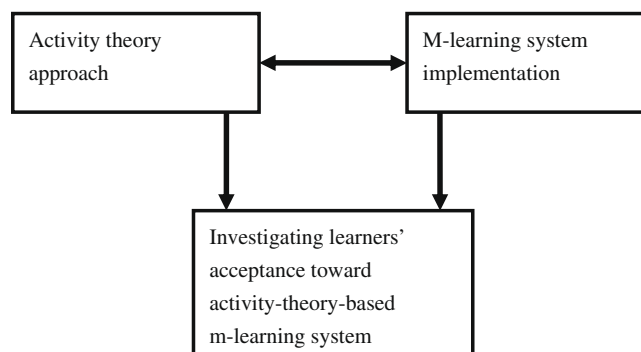


Fig. 5. The research concept.

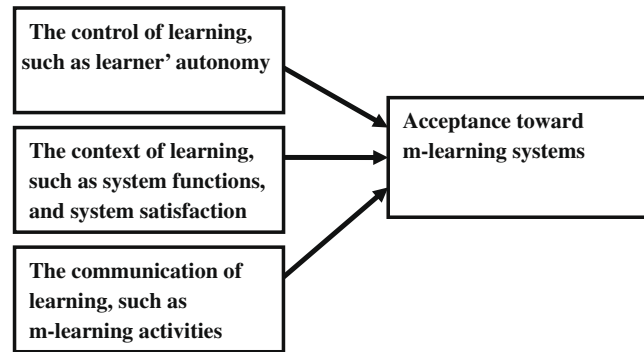


Fig. 6. Learners' attitudes toward m-learning system.

Table 2

Descriptive statistics of attitudes toward PDA operating skills (from 1 which means "no experience" to 7 which means "well experienced").

Variables	M	SD
I know how to operate the PDA hardware	2.61	1.51
I know how to operate the PDA software	2.63	1.61
I know how to operate the PDA browser	2.74	1.67

Table 3

Descriptive statistics of attitudes toward PDA as a knowledge management tool (from 1 which means "no experience" to 7 which means "well experienced").

Variables	M	SD
<i>System activities</i>	4.79	1.38
The m-learning system as a convenience tool for reading online content	4.68	1.64
The m-learning system as a convenience tool for retrieving online content	4.78	1.40
The m-learning system as a convenience tool for human–computer interaction	4.91	1.46
<i>System satisfaction</i>	4.31	1.52
Enjoyment of using the m-learning system for retrieving online content	4.31	1.53
Enjoyment of using the m-learning system for gathering online resources	4.31	1.56
<i>Learners' autonomy</i>	4.02	1.73
The m-learning system as an autonomous tool for gathering online resources	4.03	1.75
The m-learning system as an autonomous tool for retrieving online content	4.02	1.76
<i>System functions</i>	5.51	1.25
The m-learning system as an easy tool for use	5.60	1.35
The m-learning system as an easy tool for gathering online resources	5.67	1.40
The m-learning system as an easy tool for retrieving online content	5.26	1.44
<i>System acceptance</i>	4.39	1.40
The m-learning system as a tool for enhancing problem-solving	4.50	1.53
The m-learning system as a tool for enhancing knowledge management	4.32	1.47
The m-learning system as a tool for enhancing for knowledge construction	4.36	1.56

Table 4

Regression results.

Dependent variable	Independent variables	β	R^2 change	p
System acceptance	System satisfaction	0.31	0.61	<0.001
	Learners' autonomy	0.40	0.09	<0.001
	System functions	0.19	0.03	<0.001
	System activities	0.12	0.01	0.042

"no experience" to 7 which means "highly experienced"). The questionnaire items were mainly referred from the research of Liaw, Chen, and Huang (2008) and the research of Liaw et al. (2007). The alpha reliability of these two studies were highly accepted ($\alpha = 0.96$ and $\alpha = 0.92$).

Statistical analyzes revealed that alpha reliability of attitudes toward the system was highly accepted ($\alpha = 0.96$). Descriptive statistics (means (M) and standard deviations (SD)) are shown in Table 2. Descriptive statistics of attitudes toward the system are shown in Table 3. From the Table 3, users' have positive attitudes toward using the system.

Regression analyzes revealed four independent variables, system satisfaction, system activities, learners' autonomy, and system functions. All variables were positive predictors on system acceptance (acceptance the m-learning system as a knowledge management tool). System satisfaction was the biggest contributor (61%). The results are presented in Table 4.

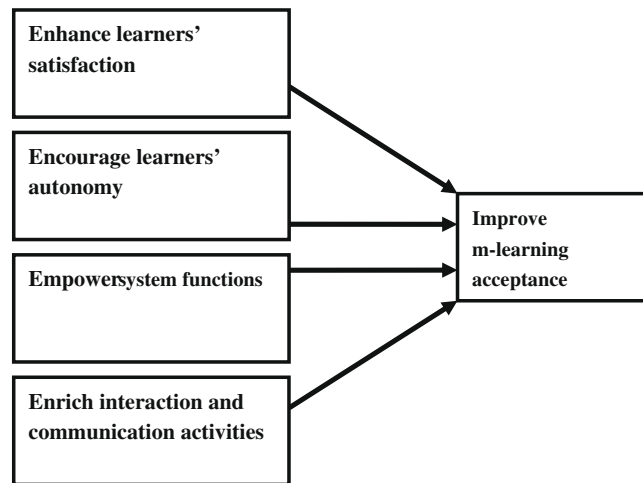


Fig. 7. The acceptance conceptual model of m-learning.

6. Discussion and conclusion

Learning activities include complex cognitive and social processes that are necessarily to interact with the world around it. m-Learning systems provide opportunities for learners to communicate with the real world and to search interdisciplinary domains. Activity theory provides an alternative lens for analyzing learning processes and outcomes that capture more of the complexity and integration with the context and community that surround and support it.

The results support previous studies (Chen, Lin, & Kinshuk, 2008; Liaw, 2005; Wang, 2003) which found that the system satisfaction is a key predictive factor on system acceptance; in addition, the results also support prior research (Liaw et al., 2007) that learners' autonomy was major contributor to system acceptance. Furthermore, this study provides evidence that system activities and system functions are also significant factors on system acceptance.

Based on the researching findings, we propose a theoretical conceptual model when applying m-learning. Four affordances will improve the acceptance of m-learning systems: enhance learners' satisfaction, encourage learners' autonomy, empower system functions, and enrich interaction and communication activities. Fig. 7 explicates the conceptual model. Indeed, from the educational viewpoint, how to spark acceptance of m-learning systems is a fundamental issue for empowering learning effects.

Based on the research findings, we may classify affordances of m-learning in education into five applications:

Educational content and knowledge delivery application: This application tends to create m-learning platforms on handheld devices to provide various educational services for both learners and teachers. In one example, mobile devices were used to help health students in the community access learning resources provided by library (Walton, Childs, & Blenkinsopp, 2005). Likewise, this research uses handheld devices to retrieve resources from the Internet to assist learners to construct and share knowledge. Within this application, handheld devices are used as a means for sending and receiving educational information and resources for ubiquitous access.

Adaptive learning application: This application refers to the designed learning environments in which content development tools are built to deliver learning content adaptively to mobile devices. For example, like our system, a combined adaptive learning system for use on both desktop computers and mobile devices at university level (Bull & Reid, 2004). Besides, Kuo and Huang (2009) developed an adaptable mobile learning resource system for learning content and test items and the results indicated the system provided adaptable learning content and test items.

Interactive application: This application focuses on creating mobile learning systems, sometimes with other technologies such as personal computers, to increase interaction or communication between students and the teacher. For instance, Weber, Yow, and Soong (2005) created a wireless m-learning system to increase interactivity and communication between students and the instructor.

Individual application: Such application provides information and services via mobile devices to users according to users' location and/or needs. Cui and Bull (2005) developed a mobile tutoring system that allowed the language learners using it for personal grammar learning. In another example, ubiquitous learning devices supported personalized knowledge awareness (El-Bishouty, Ogata, & Yano, 2007). Their results indicated that learners are satisfied with mobile devices that assist personalized knowledge awareness.

Collaborative application: This application makes use of the available communication and interaction features of mobile devices to encourage knowledge sharing and construction of new knowledge. In one example, Lai and Wu (2006) developed a collaborative learning environment using handheld devices to share learning materials.

In summary, this research provides evidences to show that m-learning can facilitate and assist users' knowledge management. In general, knowledge can be viewed as information in context, together with an understanding of how to find it and how to use it. Knowledge management should be investigated based on self-directed searching, construction, and sharing. The purpose of this research is to develop an m-learning system that based on activity theory perspective to help learners find, retrieve, manage and share knowledge. Within the boundaries of information systems, users tend to focus their efforts on knowledge that is explicit, or mechanistic in nature. As knowledge is filtered through the activity theory approach, it gradually becomes classified, codified, and documented. As a result, knowledge is captured by individuals in the explicit format. Although tacit knowledge is difficult to formalize and translate (Nonaka & Takeuchi, 1995), it can be transferred through personal mental concepts, technical skills, and experience (Choi & Lee, 2002). Based on the activity theory

approach, the m-learning system offers a strategy that enables individuals to employ and sharpen their tacit knowledge into explicit formats. Therefore, the functions of m-learning systems provide opportunities for users to create their own knowledge based on their mental concepts and prior experience. Additionally, users can share their knowledge based on their constructed knowledge.

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