

A Three-level Evaluation Framework For a Systematic Review of Contextual Mobile Learning

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ABSTRACT

The rising popularity of contextual and location-based mobile learning in recent years calls for serious evaluation methods about learning efficacy both in formal and informal settings. Although several empirical studies give evidence showing the effects and effectiveness of mobile learning in general, there remains a lack of evaluation models that examine the efficacy of contextual mobile learning. This paper aims to build a holistic evaluation framework on contextual mobile learning and to apply the framework to evaluate previous empirical research by conducting a systematic review. The proposed framework has three levels: (a) the external level consisting of social, cultural, and technical factors; (b) the inter-medium level consisting of content, context and device; and (c) the internal level focusing on learners' attitude and experience. The analysis of 28 empirical studies on contextual mobile learning was conducted through a comparison and contrast method at all three levels. The review revealed that most of the previous studies conducted evaluation at the inter-medium and the internal levels, and there is lack of investigation on factors at the external level. In conclusion, we discuss the significance and implications of integrating all three levels in examining the efficacy of contextual mobile learning research.

Author Keywords

Contextual mobile learning, evaluation framework, social-cultural factors

INTRODUCTION

Mobile learning research in recent years has shifted its focus from theoretical to practical and integrated issues. Brown et al. (2010) propose that mobile learning is not only about the mobility of the learners and devices, but also the mobility of learning across contexts. According to Hansen and Bouvin (2009), "Learning does not occur in a void: it is by its very nature contextualized, and it is by linking and applying new knowledge and experience with the context of what is already known that learning is achieved" (p.19). Likewise, Pachler et al. (2010) posit that context in location-based mobile learning can be seen as interactive negotiation by the learner with their natural environment. Simultaneously, the nature of learning is being augmented and accelerated by new digital tools and media, which provide adaptive supports to the learners while sensing the personal and environmental contexts (Hwang, et al., 2009; Pachler et al., 2010). Context-aware computing technology can be used to support contextual learning in various environments such as field trips and virtual reality (e.g., Forsyth, 1986; Hwang, et al., 2009; Michie, 1998; Patten, et al., 2006).

From the pedagogical perspectives of mobile learning, we employ situated learning and contextual learning as theoretical frameworks for this study. Situated learning theory posits that learning is situated within authentic activities, context, and culture. Learning is more likely to take place when information is contextually relevant to the learner and when information can be put to use immediately (Lave & Wenger, 1991). A few scholars have constructed such theoretical perspectives on contextual mobile learning that emphasize the situated nature of human interaction and learning. For example, Tan et al. (2011) propose the 5R adaptation concept for location-based mobile learning which is stated as follows: at the right time, in the right location, through the right device, providing the right contents to the right learner. Likewise, Tan and So (2011) developed the 'FAT' (Facilitation - Activities - Technology) framework to guide the design of contextual and location-based mobile learning. Those frameworks are applicable to the evaluation of the situated aspects of mobile learning, mobile application design, intervention plans (mostly on learning content) or contextual influences. With respect to more comprehensive evaluation of contextual and situated mobile learning, there are several good practices such as the FRAME model developed by Koole (2009) and the M3 evaluation framework proposed by Vavoula et al. (2009). The FRAME model refers to psychological concepts such as Activity Theory and emphasizes on the role of mobile devices. This model helps practitioners reflect on their mobile learning approaches and assess the extent to which learners are engaged in balanced and effective mobile learning experiences (Koole, 2009). The M3 (micro-, meso- and macro-levels) framework can be used to evaluate the technology development process, from the very early stages of design to the final assessment of the technology in a learning context. Considering the lack of evaluation models that examine the efficacy of contextual mobile learning from situated learning perspectives, this paper aims to build a holistic evaluation framework on contextual mobile learning and to apply the framework to evaluate previous empirical research by conducting a systematic review.

THREE-LEVEL EVALUATION FRAMEWORK

In the FRAME model, Koole (2009) considered a three-way relationship between mobile technologies, human learning capacities, and social interaction in the process of mobile learning. We broaden this conceptualization by examining contextual mobile learning at three inter-related levels (see Figure 1). Social, cultural and technical factors are taken into consideration at the external level; content, context and device at the inter-medium level; the learners' attitude and experience at the internal level. 'Context' in this paper refers to the combination of people, the environment and the interactions amongst different people as well as the interactions between people and the environment. It is a dynamic and interrelated system since any part of which, influences every other part. In the proposed framework, the elements of context would be integrated into each level, and all the three levels are influencing and are influenced by each other. In other words, the context of contextual mobile learning in this paper has different meanings at different levels. We describe the details of three-level components in the section below.

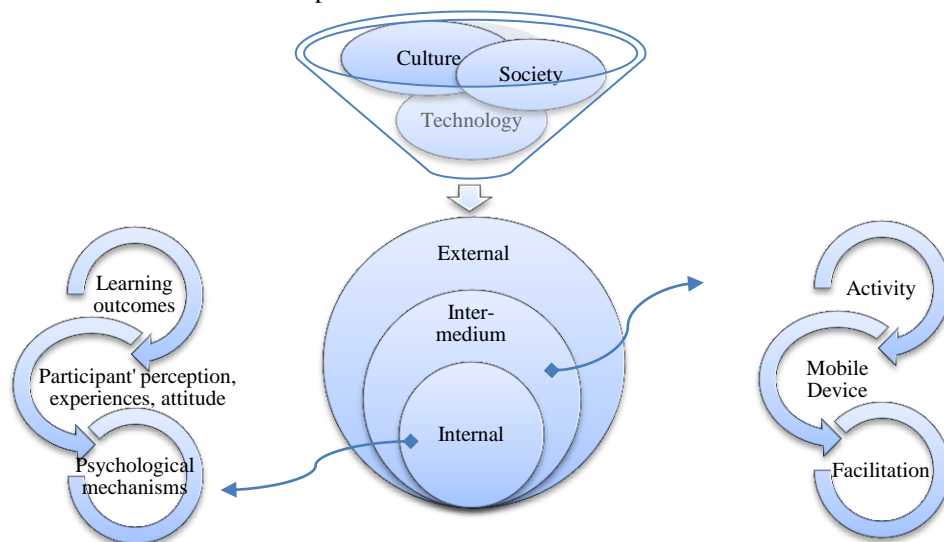


Figure 1 Three-level evaluation framework for contextual mobile learning

The External Level

Context at the external level refers to cultural readiness, societal maturity, and technological advancement. Inter-related technological, social, and cultural changes are affecting the content and the context of learning in our daily life. Technological advances make information readily accessible and can support contextual mobile learning in novel ways. Now anyone with an Internet-enabled cellphone can access databases of texts, videos and audio information on the go (Klopfer & Squire, 2007). Anyone can learn across physical contexts and time scales with the affordance of mobile technology and web-based applications (So et al., 2010). Social interaction and collaboration are also essential components of contextual mobile learning. Boticki et al. (2009) argued that community is one of the contextual dimensions to be considered in designing context-aware technology applications, and a knowledge sharing culture is needed in a community of learners for effective contextual mobile learning.

The Inter-medium Level

Context at the inter-medium level consists of the specific aspects and issues that are relevant in the design of and the implementation of mobile learning activities. Context at the inter-medium level is filtered from the external level and is situated at a certain level of social acceptance, technology advancement, and cultural support. Based on the conceptual framework for the design of situated learning environments by Choi and Hannafin (1995) and the 'F.A.T' framework developed by Tan and So(2011), three aspects are included at the inter-medium level: (a) activity design in terms of different types of context and content, (b) facilitations, and (c) the use of mobile devices.

First, referring to the two-dimensional framework of mobile learning space by So (2008), and to the notion of context proposed by Breuer and Matsumoto (2011), the type of context could be identified by whether the environment is a closed space (e.g., a museum) or an open space and whether learning occurs in a virtual-world (e.g., augmented reality) or real-world. Context can also be a combination of any of the above, since some mobile learning studies attempt to do seamless learning or ubiquitous learning by bridging formal and informal learning with the use of both real-world and digital-world resources. The type of content can be categorized by different subject areas (e.g., science, social studies, etc.) learned or experienced in a mobile learning context. Second, facilitation refers to 'Who' facilitates 'What' and 'How' in a specific mobile learning context. Facilitators can be human, computers, a combination of both, or even self-directed learners. Computer-mediated facilitation can be divided into asynchronous and synchronous communication amongst participants in a mobile learning scenario. In terms of 'What', facilitation can be used to guide content knowledge, soft skills, and logistical or technical issues. 'How' refers to facilitation methods, which consist of modeling,

scaffolding, coaching, collaborating and fading as well as using cognitive tools and resources (Choi & Hannafin, 1995). Lastly, mobile devices refer to the various technological tools that are used in mobile learning, such as PDAs, tablet PCs, mobile phones, and pocket PCs. The role of mobile devices can be seen from the pedagogical framework model by Park (2011) in which individualized and socialized activities are mediated by asynchronous and synchronous communication. In this paper, the interplay among activity design, facilitations and the use of mobile devices in the evaluation of contextual mobile learning will be discussed with specific cases reported in previous research.

The Internal Level

Context at the internal level reflects learners' experiences, attitudes and perspectives. Context at the internal level is influenced by the environment at the external level and is situated within the frame at the inter-medium level. Positive and negative effects on the learners from the other two levels should be systematically and critically investigated at this level to evaluate contextual mobile learning. Evaluation of the learners' aspect can be conducted along the dimensions of learning achievement, learning attitude, cognitive load and perception of the mobile learning system (Yang & Lin, 2010; Hwang et al., 2010; Wu et al., 2010). In the FRAME model by Koole (2009), individuals' cognitive abilities, memory, prior knowledge, emotions, and possible motivations are included in the learner aspect. In terms of device usability, psychological comfort affects cognitive load and the speed with which users can perform certain tasks (Koole, 2009).

This paper categorizes evaluation at the internal level in terms of learning outcomes, participants' attitude, perception and experiences, and psychological mechanisms. Here psychological mechanisms refer to cognitive tools that are integrated into mobile learning systems or curriculum designs. The adoptions of these cognitive tools are based on prior psychological studies with both technological and pedagogical concerns. For example, in Wu et al. (2012), the cognitive apprenticeship strategy and a context-aware ubiquitous learning environment are combined in nursing skill training during which students are provided with both personalized guidance and instant feedback and supplementary materials. In Zhang et al. (2010), by adopting the metaphor of deconstructing and reconstructing, a collective curriculum mobilization cycle comprising of six steps, namely, deconstructing, brainstorming, composing, reconstructing, implementing and summative evaluating, is developed for both in-class learning and out-of-class learning. The effects of those cognitive tools on the learners can be either positive or negative: positive effects can be improvement in learning effectiveness and learning attitude while negative effects could arise from information overload and increased cognitive load.

METHOD

Inclusion and Exclusion Criteria

Given that there is lack of holistic evaluation frameworks on contextual mobile learning, the systematic review was conducted to analyze previous empirical studies published in journals. A two-step literature search was conducted from February 2012 to April 2012 for this review. First, we began with search terms such as 'location-based and/or contextual mobile learning', 'context aware mobile learning', 'situated mobile learning'. A comprehensive search was done in the following databases: (a) ERIC via EBSCO, (b) EdITLib, (c) Education Research Complete, and (d) Ingenta Connect. Second, references in the articles were searched using the 'snowball' method. Articles surfacing only theoretical models, the designs of new architecture or products, or literature reviews, were excluded.

Data Extraction

The following data were extracted from the selected research articles: author names and date of publication, sample size, subject areas, research design, and study focus, learning design, mobile devices and facilitation. An in-depth coding process was carried out for the selected papers according to the three-level evaluation framework and the coding scheme (see details in Table 1). Elements at the external level are not included in the coding scheme since they are intangible factors and are rarely mentioned in the selected research papers.

Variable	Description	Coding Criteria
Year	Year study was conducted	Year
Population	Sample population	P – Primary; S – Secondary; H – high school; UG – Undergraduate; Gr – Graduate; Others
Sample size	Size of sample population	Leave blank or actual number of subjects
Subject area	Content area taught	L – Languages; S – Natural Sciences; SS – Social Sciences; Math – Math; Others
Methodology	Research method used	Quantitative; Qualitative; Mixed methods; Others
Focus of study	What was the main focus of the study in terms of evaluation/evaluation?	LO – Learning outcomes; PAPE – Participants' attitude, perspective and experiences; PM – Psychological mechanisms Others
Learning design	Type of learning context	Open; Close; Virtual; Real; Others
Mobile device	What kind of mobile device is used?	MP – Mobile phone; PDAs – PDAs; PPCs – Pocket PCs; TPCs – Tablet PCs; DC – Digital cameras; DVD – DVDs; Others

Facilitations	Who	Human; Computer; Both human and computer; Self-directed; Others
	What	CK – Content knowledge; SS – Soft skills; TS – Technical support; LS – Logistic support; Others
	How (Facilitation methods)	Modeling; Scaffolding; Coaching, guiding, and advising; Collaborating; Fading; Using cognitive tools and resources; Others

Table 1. Coding of research papers reviewed

RESULTS

Twenty-eight papers (indicated with * in the reference section) met the inclusion criteria for the current review on the evaluation of contextual mobile learning. The subject area and sample population of the reviewed papers vary greatly. These papers were similar in scope, but addressed a range of different aspects of evaluation and adopted a variety of methodological approaches. To organize the selected papers for a closer examination, different categories were created depending on the adopted research methodology and the main research focus of each paper by means of a constant comparison method. The categories used and the number of papers under each of these categories are shown in Tables 2 and 3 respectively.

With respect to research methodology types used in the 28 articles, we found that mixed methodology is more frequently used than either quantitative or qualitative methodology alone (see Table 2), Reliability and validity measures are rarely reported (n=3) or inconclusive due to small sample sizes or short intervention period in several articles.

Research Methodology			
Quantitative	Qualitative	Mixed	Total
5	5	18	28

Table 2. Number of papers in terms of research methodology types

Focus of Study	No. of Studies
Learning outcomes	21
Participants' attitude, perceptions, and experiences	12
Psychological mechanisms	2

Table 3. Number of papers in terms of the focus of research study

As shown in Table 3 (each paper may have more than one focus of study), most of the papers conduct evaluation at the internal level, with respect to learning outcomes (n=21); participants' attitude, experiences, and perspectives (n=12). Regarding psychological mechanisms, only 2 papers reported the psychological concerns and indications in the designs and implementations of contextual mobile learning. Overall, this review found that despite the fact that activity designs and facilitations are explained in several papers, most of them focus their evaluation on the effectiveness of technical systems or platforms. At the external level, four papers mentioned social-cultural factors (Huang et al., 2010; Klopfer & Squire, 2007; So et al., 2010; Tan et al., 2011). Two papers (Pfeiffera et al., 2009; Vavoula et al. 2009) conducted evaluation across multiple levels using the M3 evaluation framework.

Evaluation at the External Level

Evaluation at the external level aims at gaining deeper understandings of why the development of contextual mobile learning varies from cultural, societal, and technological perspectives at a macro level. Although some frameworks on contextual mobile learning have taken into account both technical and social aspects (e.g., FRAME from Koole, 2009; Context Hierarchy from Lonsdale et al., 2004) and socio-cultural factors (e.g., So et al., 2010), there is no clear evaluation method at the external level thus far. Cultural readiness in schools plays significant roles in the implementation of mobile learning activities and the use of mobile technologies. Enculturation towards contextual mobile learning is challenging, considering the dominant paradigm of education in schools that mainly focuses on the mastery of vast content knowledge at the abstract level (So et al., 2010). In the social context, field experiences mediated by mobile technologies can help learners become more connected with social networks based on friendship, collaboration, and information exchange (Huang et al., 2010).

Evaluation at the Inter-medium Level

Evaluation at the inter-medium level is to investigate how contextual mobile learning is implemented under a certain cultural or social situation. In contextual mobile learning, students are guided not only to learn with mobile devices in authentic contexts (Uden, 2007; Hwang, Tsai, & Yang, 2008), but also to generate location-based or context-specific content in the process of learning. In the context of collaborative mobile learning, the intricate relationship among task design, facilitation and the discourse types was investigated in Tan and So (2010). In their study, activity design includes structured and unstructured learning activities. Both content and context are measured along different dimensions. Facilitation, on the other hand, is assessed in terms of 'who', 'what' and 'how'. Because an evaluation framework in this

paper is not technology-centered and we believe that the main barriers to developing contextual mobile learning are more social than technical (Sharples, 2010), our analysis places emphasis on evaluation in terms of activity design and facilitation types.

Evaluation In Terms of Activity Design

Learner-centered activity calls for unstructured engagement more than structured engagement. Although structured tasks are still needed for guiding learning process (Hsiao et al. 2010; Tan & So, 2010), unstructured activities should also be included in the mobile learning design to provide space for more self-directed learning. In Rogers et al. (2004), the learning activities were designed in a much less structured fashion compared to task-oriented field trips in order to promote more independent and student-initiated scientific inquiry. In Huang et al. (2010), learners spent roughly a half of the course time for various activities, interacting with their peers, the environment, and the course instructor. In Shih et al. (2010), learning content and activities related to the historic site and teaching were designed and carried out at three learning stages to support students' cognitive learning, and to increase their inquisitive learning ability. In So et al. (2009), various repairing strategies were made after a pilot study to improve learning scenarios and to make the activities less structured and cater to the students' self-directed interest in contextual mobile learning. The type of context can be sorted by whether the learning environment is a closed space or an open space and whether it is in virtual-world or real-world. For example, in Cheverst et al. (2000), GUIDE, an intelligent electronic tourist guide system, was used to present city visitors with information tailored to both their personal and environmental contexts. This mobile learning environment is in an open space with the integration of real and virtual resources. In Shih et al. (2010), learning activities were designed between the field and the digital system to demonstrate the practices of mobile learning and to provide digital learning contents to facilitate students' field studies. Learning activities took place in a temple, thus the type of context is an integration of real and virtual in a closed learning space.

Evaluation In Terms of Technical Support

As mentioned before, technological support in the 28 papers are categorized by different mobile devices. The evaluation of technical support is not only about mobile devices but also about learning platforms/systems. As an example, the evaluation of Myartspace (Vavoula et al., 2009) focuses on three levels following the M3 evaluation framework, which is also adopted in the study by Pfeiffera et al. (2009) about fish biodiversity learning via mobile devices in a situated learning scenario.

Evaluation In Terms of Facilitations

In the analysis of the 28 papers, we find that facilitations are mostly explained and coupled with descriptions of activity designs or learning processes. In Shih et al. (2010), there was a warm-up activity (i.e., PDA orientation) before the first stage activity designed to provide the students with basic knowledge, and to stimulate their learning. In Hsiao et al. (2010), facilitations are provide at four stages of learning to arouse student interest in the tasks, to increase their sensitivity to the environment, and to have them experience a natural environment and develop self-awareness with joy. As argued by Tan and So (2010), too structured facilitation would influence learning outcomes leaving little space for learners to exercise reflective thinking skills. Facilitations are categorized in terms of 'who', 'what' and 'how' in this paper. In terms of 'Who', facilitators in most of the studies are the combination of both human and computers. Human and computer are facilitating in different ways from different aspects. For example, in Wu et al. (2012), technical support was given by human facilitators whereas helpful content knowledge was provided by computers. In terms of 'What', facilitations in most of the studies are about content knowledge; 11 out of 28 papers discussed technical support and 2 papers about logistical support. In terms of 'How', guiding is used in almost all the studies, and scaffolding is also widely used as a facilitation strategy.

Integration of Facilitation, Activity, and Technology

Through the categorization of 28 papers, we found that the three aspects of *facilitation*, *activity* and *technology* are highly inter-related. They influence each other, and the balance among them is reached in a few studies. For instance, Shih et al. (2010) employed an inquiry-based mobile learning approach with the use of PDA and designed learning activities between the field and the digital system. Computer and people are both facilitating the students by scaffolding, guiding and using cognitive tools. Cognitive load is also considered in the design of the digital system and in the implementation of learning activities. Likewise, in Wu et al. (2012), a cognitive apprenticeship strategy was built into a mobile system for physical evaluation in nursing skills training. The system has a fading function where the amount of support is gradually reduced to the students if their knowledge or skills have achieved at some pre-determined levels. Technical support and helpful content knowledge were provided by human and computer facilitators. The results show that both knowledge and skill levels were promoted effectively.

Evaluation at the Internal Level

Evaluation at the internal level focuses on the learners. It aims to examine learning efficacy at both individual and community levels and how learners are situated in different contexts of mobile learning. As seen in Table 3, 21 papers focus their evaluation on learning outcomes, and 12 papers on participants' attitude, experiences and perspectives. The twelve studies carried out the evaluation from students' perceptions and learning outcomes, regarding the usability of mobile technology (e.g., Hwang et al., 2011; Wu et al., 2012; Yang and Lin, 2010). Only 2 papers illustrated the psychological mechanisms situated in their mobile learning designs and pedagogical implementations. Statistically positive outcomes are found in all 28 papers. For example, in Chen et al (2008), students' understanding of the 3Rs

(Reduce, Reuse, Recycle) and their understanding through the application of the 3Rs concepts were improved with the affordance of technology as well as cognitive and pedagogical tools (learning outcomes and psychological mechanisms). In Huizenga et al. (2009), with the assistance of the new mobile learning platform, both the learning efficiency and the learning achievement of the students were significantly improved (learning outcomes). In Hsiao et al.'s study (2010), the results showed that the experimental group outperformed the control group on the ecological knowledge test. Furthermore, the students in the experimental group felt satisfied with the ecological learning system supported by positioning systems (participants' attitude, experiences and perspectives).

DISCUSSION

Integration of Three-Level Factors

Evaluation at each level is independent yet closely related to the other two levels. Technology, mediation of individualized and social activities in contextual mobile learning are integrated with activity design and facilitation. All three aspects should serve to meet the learners' needs. Pedagogical concerns and the use of cognitive tools are influencing and being influenced by learners' attitude, perspectives, and experiences as well as learning outcomes. Implications from psychological studies of learning and human interaction are also essential in mobile learning interventions where learning experiences are triggered on the move by being situated in the continually unfolding contexts. Contextual mobile learning is not simply about the delivery of content, but about the augmentation of human activities in situated contexts. Hence, it is imperative to examine how contextual mobile learning can be supported by various learning scenarios, how mobile technologies or devices are being used and how contexts for learning are artfully created through continual interactions among people, technology, and settings (Brown et al., 2010; Sharples et al., 2009). A cycle displayed in Figure 2 below is to visualize all those factors at the three levels under the sphere of contextual mobile learning.

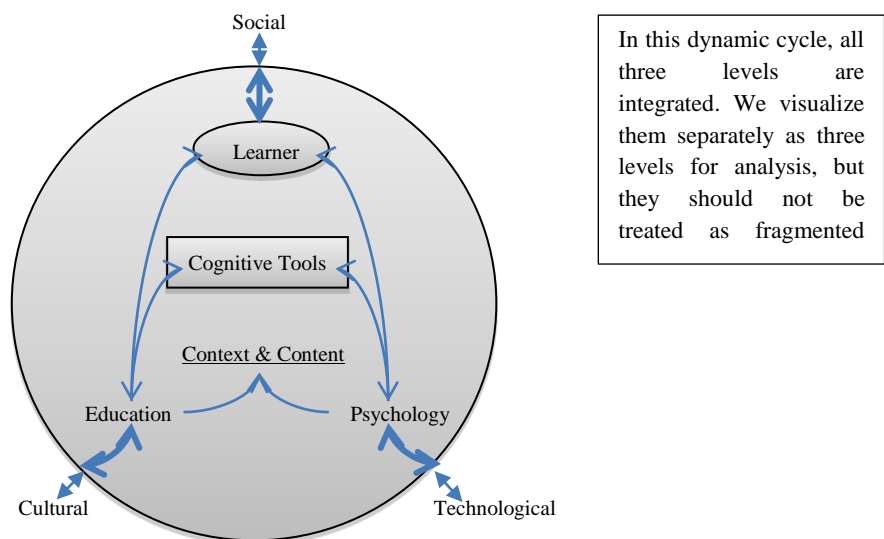


Figure 2 Integration of three-level factors

Limitations, Future Research and Challenges

This paper suggests that, while there are some challenges, the future of mobile learning in the new era is promising when all three levels in the proposed framework are well integrated into the design, enactment and evaluation process. Although the three-level evaluation framework is applied to the systematic review of 28 papers about contextual mobile learning, it leaves open whether there are some other prominent factors that should be considered in or out of all three levels. Our understanding of the root value of education is often limited by the prevailing paradigm of learning, and we should look closely beyond superficial effects of novel modes of learning. Although mobile and social technologies are deployed to blur the boundaries between the real and the virtual space and between the open and the closed learning environment, the main barriers to transform learning are not technical but social. Because macro-level factors at societal and cultural levels are intangible and are seldom discussed in detail in empirical studies, currently the evaluation of contextual mobile learning at the external level is core but lack of evidence.

The evaluation of how and to what extent different learning styles and different levels of context awareness influence learning outcomes are not covered in this study. Additionally, this paper does not discuss ethical implications and differentiations in the three levels of different subjects and different education levels. Last but not least, our limited understanding of mobile learning environments, the range of learning abilities and learning preferences among different people are the obstacles and challenges for an evaluation of learning in a contextual mobile learning context.

CONCLUSIONS

The three-level framework developed in this paper provides one possible way for evaluating contextual mobile learning with the introspective method on the whole. At the external level, when socio-cultural conditions are conducive to the mobile learning approaches and when knowledge sharing culture emerges naturally, we can make effective use of the advanced mobile technology for situated and contextual learning. At the inter-medium level, a good design should infuse well-structured facilitations, interesting activities and proper mobile learning platforms/devices. At the internal level, the learning approach and the whole design should not only enhance learning motivation, but also improve the cognitive achievements of the learners. The proposed framework provides a systematic structure in evaluating mobile learning strategies at the organizational level, in designing mobile learning activities at the educational level and in studying learners' experiences and attitude at the users' level. From a broader point of view, continuous reflective evaluation with the proposed framework would give researchers and practitioners insights into the design, implementation, and evaluation of contextual mobile learning.

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