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REVIEW

Pedagogical Requirements for Mobile Learning: A Review on MOBIlearn Task Model

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Pedagogically sound design for mobile learning application development is a key factor for providing a pleasant and rich learning experience in a mobile environment. In the context of higher education, this need is very critical as institutions and students begin to recognize the importance of bridging the gap between formal classroom and out-of-classroom informal learning to achieve pedagogical goals. However, there are very few existing research studies on how mobile learning design could be informed specifically to support pedagogical requirements for educational mobile learning application. This paper therefore presents a review on the MOBIlearn task model framework and its contributing factors in an attempt to capture appropriate requirements by generalizing the current state of understanding and discover common grounds and similarities from previous research publications. A number of key mobile learning articles, mostly from conferences and journals containing explanation on any of the factors, have been consulted to get a deeper understanding and insights. At the end of this paper, we discuss our findings as a set of pedagogical requirements identified from the literature by categorizing them based on the task model factors in order to clearly answer our research questions and design a techno-pedagogical tool based on what we have learned in the review.

Keywords: mobile learning; pedagogical requirements; task model; techno-pedagogical tool

Introduction

Mobile learning is gradually gaining on popularity because of the increasing availability of low cost mobile and wireless devices as well as the supporting infrastructure and technology. It provides a new way to extend education outside the fixed classroom. It creates learning communities between people on the move, provides expertise on demand and supports a lifetime of learning (Sharples, 2007). In addition, it provides users with the opportunity to personally control their learning as well as to creatively own their learning processes and easily communicate with their peers (Laurillard, 2007; Wong, 2012). According to Klopfer and Squire (2008), mobile learning produces unique educational advantages such as portability, social interactivity, context sensitivity, connectivity and individuality. Agha and Ayse (2011) have pointed out that mobile learning provides a personalized platform of learning content where convenience in the access of resources is very critical. A recent study (Wong, 2012) has mentioned that mobile learning is about increasing learners' capability to physically move their personal learning environment as they move. Bruck, Motiwalla and Foerster (2012) have explained that mobile learning could better cater for the learners' need for learning in situations of limited time or real time. As a mobile device is generally owned and always carried by a student, a one-to-one relationship is created which could provide the ability to learn anywhere, anytime and at any pace.

However, research has consistently shown that designing a mobile learning application to support pedagogical purposes is a very challenging task mainly due to the different value systems of users from various backgrounds and experience (Huang, 2009). Despite its flexibility and affordability, mobile learning is still in early development stages with both technological and pedagogical limitations (Liaw, Hatala and Huang, 2010). Moreover, it still lacks standardization with respect to specific requirements for educational practices (Nestel et al., 2010; Barbosa, 2013). As indicated by Churchill (2011), contemporary research on technology in teaching and learning pays insufficient attention to the pedagogical design of educationally useful mobile applications and their roles in learning experiences. One of the pedagogical challenges stated by Mor and Mogilevsky (2012) is how to connect the theories and case studies to students' experience in a mobile learning environment. Additionally, Heng, Sangodiah and Ahmad (2012) have stated that many higher educational providers are having difficulty in developing an effective mobile application to support a pedagogical model of mobile learning. Even after more than ten years of research in mobile learning, none of the work

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has resulted in a single 'killer application' to be universally adopted in higher education (Sanchez, et al., 2009). What is worse, previous researches (Subramanya and Yi, 2006; Sharples, et al., 2007; Ching, et al., 2009) have pointed out an increasing concern about the development of existing applications for mobile learning that tend to employ design and evaluation principles taken from traditional or e-learning theories, which consequently results in mobile versions of the established tools or systems. As indicated by Bo (2005), the theoretical and pedagogical model of learning requires reappraisal or redefinition if it is to be applied to mobile learning environments. Ultimately, the focus should be on the effect of the technology on learner activities, intentions and goals as they engage in learning, rather than on what the technology can do (Taylor, 2004; Beckmann, 2010).

The significance of this study therefore rests on the fact that there is limited work on how mobile learning design could be informed specifically to support pedagogical requirements for mobile learning environments (Peters, 2007; Frohberg, Goth and Schwabe, 2009; Churchill, 2011; Agha and Ayse, 2011; Mor and Mogilevsky, 2012). There are two key rationales for this study. Firstly, in the context of designing an effective mobile learning application for educational purposes, it is not enough to have a system developed simply to be working at the level of being usable (Bo, 2005). Beyond that, the user experiences also depend on the capability of the system or application to present the contents which could be accessed and manipulated in a meaningful and pedagogically way. In other words, the usefulness of the mobile learning application is mostly determined by the ability to support the appropriate pedagogical context on which the learning process is taking place as well (Taylor and Evans, 2005). Secondly, Bo (2005) has highlighted that the contributing factors that exist in MOBIlearn task model of the analysis framework for pedagogical purposes have not been fully explored yet. This remark has reinforced the need to investigate the factors in detail to gain deeper knowledge and understanding as the previous works are simply based on typical mobile projects (Taylor, et al., 2006; Frohberg, Goth and Schawabe, 2009). It is assumed that in order to capture pedagogical requirements to inform the mobile learning pedagogical design process, it is compulsory to fully understand the factors in the model. This has not been conducted previously to such a big scale (Frohberg, Goth and Schwabe, 2009).

Understanding the factors in the task model to gain a complete picture will enable this study to answer:

1. What are the learning activities performed and resources accessed by learners in mobile environment?
2. How control, context and communication can support pedagogical needs in mobile environment?

In an effort to answer the research questions above, every factor on each layer in the model needs to be investigated. There are six factors in the model that need to be considered when designing a mobile learning system or application, which are: tool, subject, object, control, context and communication. However, this review leaves aside the tool factor, as sound pedagogy is not tied with any device or space (Sharples, Taylor and Vavoula, 2005; Taylor, et al., 2006).

In the next section, we present the task model framework generated from the MOBIlearn research project followed by its role in the analysis stage of mobile learning design as our background study. We then introduce a systematic review as methodology in order to conduct this study comprehensively. Later, we examine all the contributing factors of the model related to our review questions laid out in this section and the findings of this review are briefly discussed in the Discussion section. Finally, we conclude our study and suggest future works in the last section.6.

Task model framework for mobile learners

Mobile learning research focuses on the study of how the mobility of learners empowered by mobile technologies and infrastructure can support the process of gaining new knowledge, skills and experience (Sanchez, et al., 2009). To systematically position and review the fundamental theories, current issues and enabling technologies behind mobile learning, this study begins with an analysis framework introduced by the MOBIlearn project (Taylor, et al., 2006). This framework is chosen as it is explicitly targeted at mobile learning and has its roots in Vygotsky's sociocultural, Engestrom's activity model, and Laurillard's conversational theories of learning (Sharples, Taylor and Vavoula, 2005; Taylor, et al., 2006; Frohberg, Goth and Schwabe, 2009).

> *"The aim of the task model is to provide a coherent account of how the activities are performed, the people involved, their contexts, the tools and technologies they employ, the structure of the tasks and an account of their cognitive processes, management of knowledge, and social interactions".* (Taylor, et al., 2006, p.15)

The key aspect of the model is the focus given on the learner being mobile, rather than defining mobile learning as learning that takes place through the use of mobile devices (Taylor, et al., 2006; Sariola, et al., 2001). As the learners move within two spaces (learning space and technological space), there are possibilities of actions which will be affected or changed by the tools, and this in turn affects the way the learners perceive and perform the activities (Vavoula and Sharples, 2009).

As shown in **Figure 1**, the upper part of the triangle consists of three elements, which are subject (learner or technology user), object (knowledge and skills or information resources) and tools to mediate the learning objective to the learner. The tools can either be the mobile learning technology, such as mobile devices and learning video or learn-space. The model is extended by adding another three elements on the lower part of the triangle, which are control (social rules or human-computer interaction), context (community or physical context), and communication (conversation or channel and protocol). The additional elements are very crucial and relevant for mobile learning in order to provide

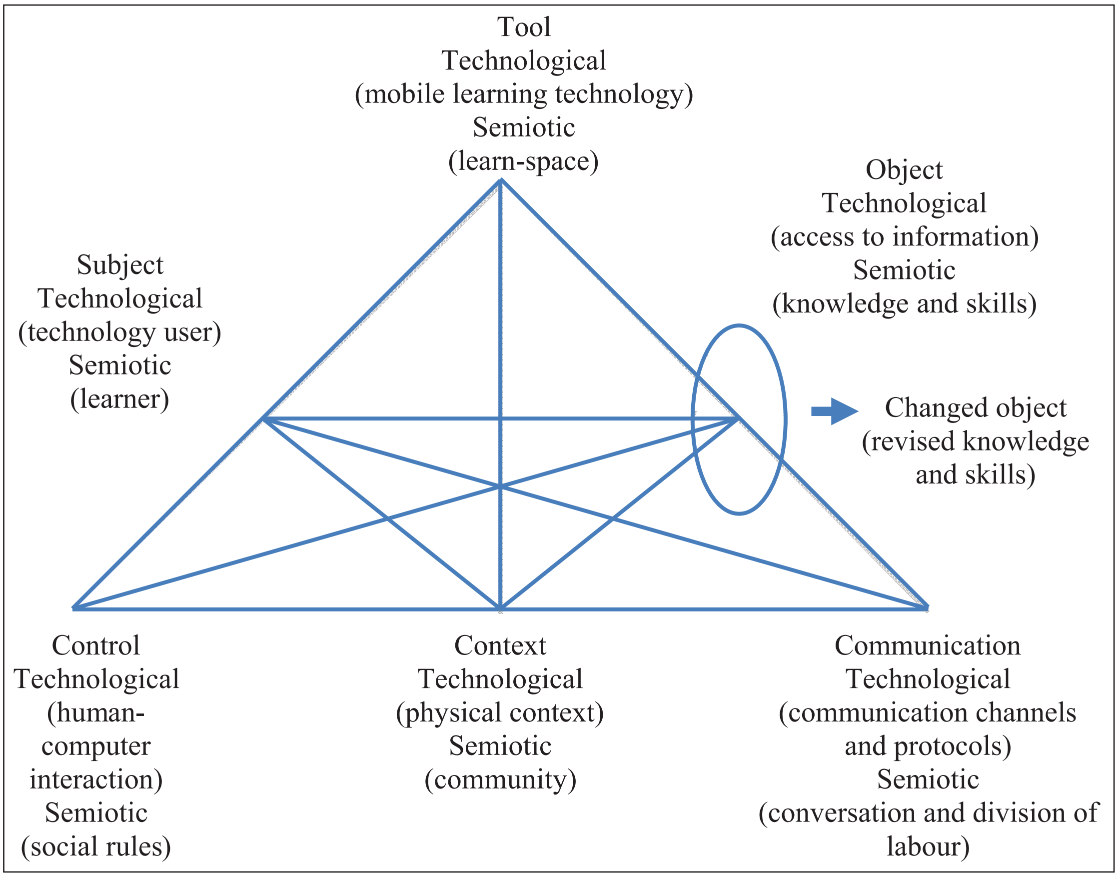

Figure 1: A task model for mobile learners (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006).

a successful educational and pedagogical environment (Sharples, Taylor and Vavoula, 2005; Taylor, et al., 2006; Frohberg, Goth and Schwabe, 2009). Each element is connected to some other element, showing the complex interdependencies among them.

Taylor, et al. (2006) have separated the framework into two perspectives, or layers, which are the semiotic layer and the technological layer to present a dialectical relationship between the pedagogical space and the technological space. The semiotic framework represents the learning as learners' actions, which are mediated by cultural tools and signs while the technological framework represents an engagement with technology in the process of learning. As the learners appropriate the technology into their learning activities, their learning behaviours in turn will be shaped by that technology. Vavoula (2005) has explained both layers of the framework in her MOBIlearn project report as in **Figure 2** and **Figure 3**.

According to the author, the learner moves in semiotic space by carrying personal objectives, intentions and projects through learn-space that provides a cognitive environment to carry out learning activities. The author has emphasized that the learning takes place in various events, employed by a variety of learning methods as well as in various social settings.

On the other side, in technological space, the technology user uses devices to access information. In addition, the author has also mentioned that human-computer interaction (HCI), communication infrastructure availability, physical context and history of use and interaction can affect the effectiveness of the learning environment.

Sharples, Taylor and Vavoula (2005) have argued that the layers can be laid over (as in **Figure 1**) to examine the holistic system of learning where the semiotic joins into the technological to form a broader category of technology than physical artefacts. The authors have also highlighted that there is no clear distinction between the semiotic and technological; instead they just want to set up a continual dynamic in which both can be moved together and apart. Therefore, they are neither proposing the separation of the semiotic and the technological, nor the blending of the two. Frohberg, Goth and Schwabe (2009) in their study have considered that even though both spaces are linked to each other, they must be viewed separately because the same technology setting can be used for a different educational approach and vice versa. Ultimately, Taylor, et al. (2006) have concluded that the semiotic or mental space where the learner moves consists of the required functionalities for learning, whilst the technological space represents the actual embodiments of those functionalities in the form of devices. In the next section, we present the role of the task model in the analysis stage of mobile learning design.

The role of the task model

The task model has been developed on the basis of a socio-cognitive engineering approach. This is a logical approach to describing and analysing the complex interactions between people and computer-based technology to

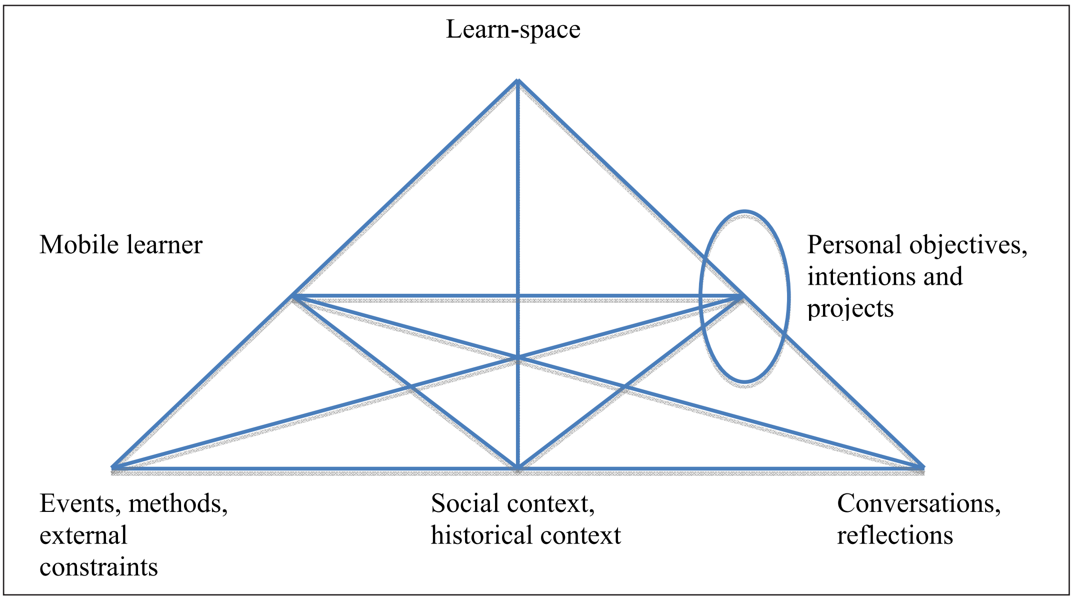

Figure 2: Mobile learning episodes in the semiotic space (Vavoula, 2005).

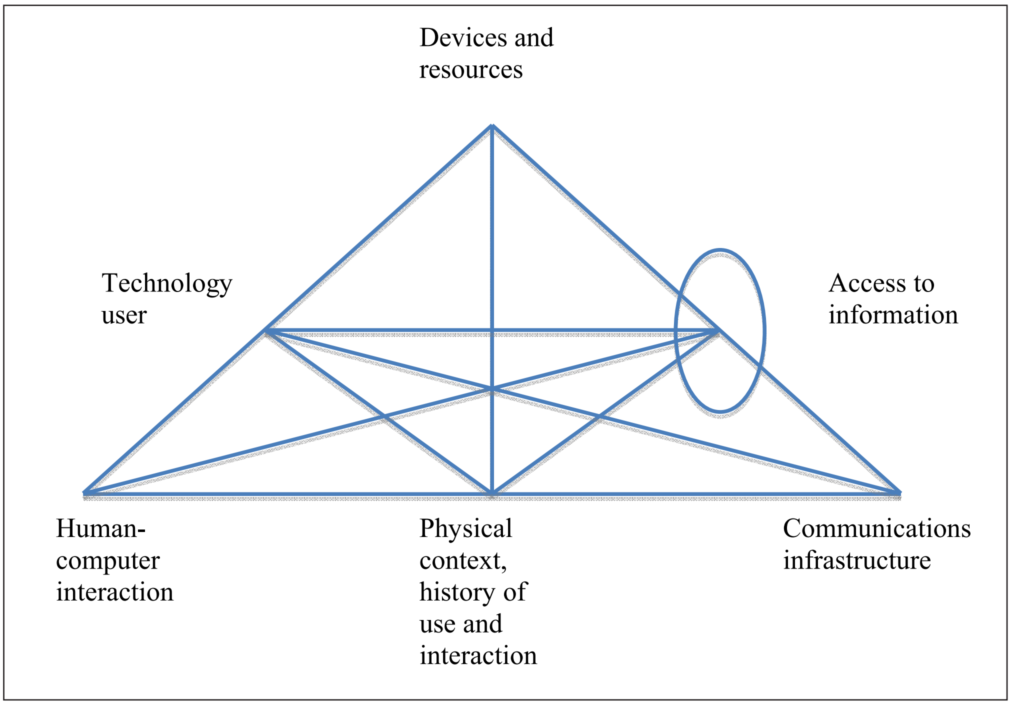

Figure 3: Mobile learning episodes in the technological space (Vavoula, 2005).

inform the design of socio-technical systems (Taylor, et al., 2006; Vavoula and Sharples, 2009). The key advantage of this approach lies in the enriched view of users' tasks and the context of use, which leads to the illumination of the dialectical relationship between users and technology (Taylor, et al., 2006). **Figure 4** shows how the task model provides a bridge to a cycle of iterative design:

The task model serves as a reference for the activity analysis stage. This stage analyses how people work and interact with their current tools and technologies and sets requirements and constraints for the subsequent design processes (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006).

As shown in the figure, the development process of the task model was started by identifying the general requirements and constraints for the system design. These requirements were captured through the use of a scenario refinement process to identify basic requirements for a mobile learning environment. This process led to two parallel studies, which were field studies, to investigate how the activities were performed in learners' normal contexts, and a theory of use to study the theories of underlying cognitive and social processes (Taylor and Evans, 2005; Taylor, et al., 2006). Both studies were assembled to synthesize a model that could provide a foundation to understand mobile learning structure coherently.

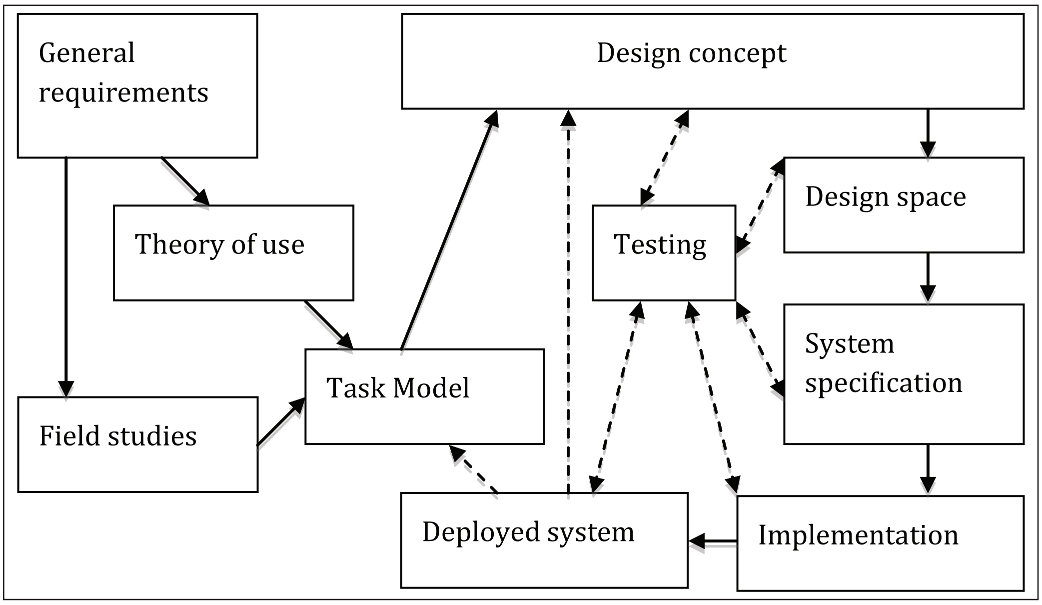

Figure 4: Flow and main product of design process (Bo, 2005; Taylor, et al., 2006).

The use of the task model has enabled the capturing of many possible interactions those learners may engage in as they move around their respective environments (Bo, 2005). The author has underlined the great advantage of this model as being that the various scenarios can be instantiated according to the requirements, which provides a common structure to an enormously complex learning situation and individualized representation. The structure of the framework enables deeper understanding of mobile learning environment as it clearly presents all the contributing factors and their interdependencies.

In the next section, we briefly introduce systematic review as our methodology to answer our research questions stated previously.

Methodology

As mentioned before, this research study investigates all the contributing factors in each layer of the task model except for the tool factor. In order to capture appropriate pedagogical requirements to inform mobile learning design, we conduct a systematic review to analyse and understand each of the factors separately. The systematic review is a methodology to perform structured analysis focused on a research question that tries to synthesize information relevant to that question through well-defined steps (Kitchenham, 2004). We chose this methodology as we believe it is rigorous, transparent and replicable and, as a result, can improve traditional literature reviews (Mallete et al. 2012). Thus, those attributes will lead to a very thorough and careful investigation, provide clear and easy to perceive understanding as well as focus on evidence-based studies.

In our context of work, we use five steps of systematic review which are: (1) framing questions for a review; (2) identifying relevant work; (3) assessing the study quality; (4) summarizing the evidence; and (5) interpreting the evidence (Khan et al., 2003).

Framing questions for a review

We have derived two research questions based on the layers of the task model: (1) what are the learning activities performed and resources accessed by learners in a mobile environment? (2) how can control, context and communication support pedagogical needs in a mobile environment? The first question is framed based on the upper layer that represents the relationship between learner and object. Meanwhile, the second question is framed based on the lower layer that contains the supporting factors of control, context and communication which we believe are very critical for pedagogical purposes. Both framed questions will guide us in the subsequent steps.

Identifying relevant work

We limit our review to the research questions that are previously established. We breakdown the questions into individual factors (subject, object, control, context and communication) in order to come up with the terms to be used in our search strategy. As mobile learning is a quite new area, we review publications starting from 2001 until 2014 so that we can understand the state-of-the-art current research. Our inclusion criteria are the primary studies that define one or some of the task model factors in order to describe the relevant pedagogical requirements for mobile learning environment and we exclude all the works that do not discuss any of them. We also limit our review on the papers or articles that we could access directly through our online database in the university's library website.

Assessing the study quality

While many of the previous studies focused on mobile learning theory, we sought to explore the educational-oriented studies which are successfully published in certain peer-reviewed journals and conference proceedings. In order to avoid bias, we include publications that report both positive and negative results. Moreover, we focus on several key researchers and authors in the mobile learning area who have contributed many significant works to provide a deeper understanding and address issues on one of the factors.

Summarizing the evidence

In this stage, we read through each of the selected papers and extract the relevant requirements or information that the researchers obtained from their previous studies. The next section of this paper presents the details of our review. To accurately present the evidence, we then summarize the requirements with their corresponding references in a table. In this form, we can see that one requirement might be presented in several studies and vice versa.

Interpreting the evidence

Once we have identified the most relevant key points related to the pedagogical requirements for mobile learning from the previous key studies, we group them into similar concepts which are corresponding to the task model contributing factors (Glazer and Strauss, 1967). By this technique, we are able to clearly assign the identified requirements related to each factor into each research question. There are other research works (Frohberg, Goth and Schwabe, 2009; Park, 2011; Pollara and Kee Broussard, 2011) that use a similar method of categorization to identify patterns of data from review. The evidence from key studies has enabled us to reason deeply in order to answer our research questions by reflecting on the synthesized information from this analysis. Such findings are detailed in the Discussion section.

The next section presents the details of our review according to each factor of the model.

Contributing factors in the task model

Subject

The subject in the pedagogical space of the task model is the mobile learner who accesses the mobile learning content through the system or application interface during the learning process in mobile environment. The very unique feature of mobile learning is that the learners are continually on the move. Sharples, Taylor and Vavoula (2005) have explained that mobile learners learn across space as they take ideas and learning resources gained in one location and apply or develop them in another. They capture data and contribute to the creation of learning materials in remote locations and make these materials available to others (Botha, Herselman and Greunen, 2010; Sharples, 2013). For example, in a study by Sharples, et al. (2007), children send photos, audio files and notes captured at a museum on a school trip to a website to be shared back in the classroom for interpretations. Learners also learn across time by revisiting the knowledge that was gained earlier in a different context providing a framework for lifetime learning (Sharples, Taylor and Vavoula, 2005; Edirisingha, Salmon and Nie, 2008; Sharples, 2013). As the learners move from topic to topic managing personal learning projects, they move in and out of engagement with technology and are interacting within their neighbourhood or on remote locations (Economides, 2008). Originally, MOBIlearn project had identified several essential learners requirements, including: support for communication and collaboration (learners, teachers, resources, groups etc.); support for capturing information, annotation of documents or resources, personalisation of information and messaging, and all processes essential to learning (e.g. preparation, reflection, archiving etc.); awareness of the context in which activities are taking place, to include awareness of other devices in the environment, other people and services; and immediate and seamless access to services, resources and people (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006; Botha, Herselman and Greunen, 2010). As pointed out by Xia, et al. (2013), the learners access and capture multimedia contents for a wide range of activities in the mobile social learning community.

According to Wong (2012), mobile devices are perfect tools for mobile learners to have rapid learning activities on the move, such as photo taking, note taking, quick communication, Internet search, and map navigation. As indicated by Vavoula (2005), the most popular learning activities are discussion, reading, note taking, information search and reflection, observations, problem solving and collaboration. The author has mentioned that learning can take place in the event ofweb surfing as well. As reported by Klopfer and Squire (2008) in their research, learners used *Google* to search for clues in the middle of an 'Environmental Detectives' game in order to locate information quickly and easily. This has suggested that a tool such as a web browser can play a part in enriching the students' educational experiences. As mobile devices are becoming part of an individual's digital life, the tools may assist learners to access Internet resources, run experiments in the field study, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world (Sharples, Corlett and Westmancott, 2002; Churchill, 2011). Peters (2007) has pointed out that learners can use mobile devices to collect and store a greater range of data, through recording of activity and keeping a reflective journal, which are later used for analysis or as a reference for discussions with their instructors.

Learning can be more effective when learners can converse with each other, by interrogating and sharing their descriptions of the world (Taylor, et al., 2006). Based on the social constructivism theory, learners learn from others by working together on the same objective, where each group member is a potential source of information. Beckmann (2010) has reported that social learning in a mobile environment enables a learner to compare his own conceptions and experiences with those of others which is fundamental to a cognitive engagement with connection between theory and practice. As explained by Zurita and Nussbaum (2004) in their research, the learners seek the available information and build up their answers based on the knowledge that each one contributes. The authors have reported that the learners enjoy and learn more by being active participants of their learning, concentrating on thought and understanding, collaborating and negotiating with their colleagues and articulating ideas with others.

Importantly, the capacity of mobile technology to deliver synchronous communication and knowledge sharing can provide pedagogical benefits especially in encouraging simultaneous personal development such as networking and socialization (Frohberg, 2004; Peters, 2007).

Object

The object factor in the task model can be regarded as information, knowledge or learning resources accessed by learners to achieve their learning goals (Taylor, et al., 2006; Frohberg, Goth and Schwabe, 2009). Knowledge is normally created in the process of social interaction and will be finally embedded in the learners (Liaw, Hatala and Huang, 2010). According to Herrington, Herrington and Mantei (2009), it is common for teachers and learners to engage in educational activity processes such as recording, sharing and reflection to support knowledge construction in order to provide reusable, sustainable and scalable resources to a wide group of students. As defined by Wong (2012), learning resources embody online data and information, teacher-created materials, student artefacts, student's online interactions such as forums, and many more to be retrieved or not in a context-aware manner. The author has emphasized that learners are supposed to be knowledge builders who treat any material that they acquire from the Internet as resources to support their sense making and knowledge construction. Previous research studies have shown that audio recording in the form of notes and feedback is an important learning resource which can help learners to clarify information, reinforce understanding on theory and reconnect their thought with subject knowledge (Nortcliffe and Middleton, 2008; Rossiter et al., 2009; Middleton, Nortcliffe and Owen, 2009). Morever, with the ability to immediately publish their observations and reflections as digital files, mobile learning will encourage them to become investigators of their own environment (Naismith, et al., 2004).

According to Vavoula and Sharples (2009), the organization and manipulation of learning objects is central to the performance of learning activities. Fortunately, there are now opportunities for people to preserve and organise digital records of their learning over a lifetime due to the evolving software packages and storage formats that support backward compatibility (Sharples, Taylor and Vavoula, 2005). This has enabled small institutions to deliver mobile learning resources simply by structuring learning around Web-based content that could be accessed from the learners' mobile devices. The learning objects should be allowed to be taken, represented or reused in any place to support just-in-time learning (Barbosa, 2013). Eventually, the resources accessed can be stored and shared in their devices or server for future learning activities such as revision and preparation (Peters, 2007; Botha, Herselman and Greunen, 2010). To prevent multimedia overload and allow access to relevant resources, there are ongoing research studies to focus on how to develop multimedia recommender for mobile devices (Xia, et al., 2013).

The most popular learning resources are the contents of conversations, and paper-based and electronic documents (Vavoula, 2005). Bruck, Motiwalla and Foerster (2012) have suggested that the learning resources must be in the form of micro-content to avoid information overload by embedding learning into everyday life. As explained by the authors, micro-content is focused, self-contained, indivisible, structured and addressable content, which integrates text, video, audio and interactive elements in short form. The authors have claimed that by delivering the resources in the small chunks that is broken down into digestible parts, the learning experiences could be enhanced as fits better into the human processor model to support knowledge retention and building. Moreover, keeping file sizes small either by technological manipulation or by simply having multiple sections could be a solution for providing learning resources with slow and intermittent Internet access (Beckmann, 2010).

To improve user experience therefore, multimedia application information which includes video, audio, phone calls, voice recognition, still images, mobile web, interactive media need to be delivered through any type of network connection and communication (Heng, Sangodiah and Ahmad, 2012; Barbosa, 2013). As mentioned by Churchill (2011), a variety of multimedia and learning resources can be delivered using mobile technology such as e-books, web pages, presentations, interactive materials, audio files and video segments which could be accessed by connecting to 3G mobile telephony network or WiFi, accessing memory devices or storage cards or through synchronization with other devices. Given the natural conditions of mobility, access to resources is continually changing as the learners move in and out of communication on the Internet or other knowledge spaces (Taylor, et al., 2006). Providing a database of resources seems more appropriate as it enables uploading and downloading lecture notes, readings as well as audio-visual recordings such as podcasts and vodcasts flexibly for both teachers and learners. According to Edirisingha and Salmon (2007), podcasts can support students to do revision and preparation for practical work, bring informal content into formal curriculum, develop active and reflective learning skills, enhance understanding of core concepts as well as enable deep engagement with learning materials which are accessed while being mobile. Despite the fact that the simple downloading of text-based or media-rich resources can be argued to provide high level constructivism, this proves very essential if the learners are about to start constructing their own understanding of complex issues (Beckmann, 2010). Furthermore, rich multimedia application provides an environment that engages learners on an emotional level to support learning and decision making process (Bacon, Windall & MacKinnon, 2011).

Control

As learning is embedded with daily activities as part of everyday life such as conversation and reading, putting learners in control of their learning is therefore one of the benefits of technology enhanced learning. The learners can access materials as and when convenient, work through the materials at their own speed, revise and recheck them as they wish. By providing control of learning, learners can manage their learning pace and style which encourages them to become more independent and competent (Liaw, Hatala and Huang, 2010). As reported by Taylor, et al. (2006), the most successful learning comes when the learner is in control of the activity, able to test ideas by performing experiments, ask questions, collaborate with other people, seek out new knowledge as well as plan new actions. Moreover, they may have control over the place (physical or virtual) and can enjoy their right over their learning content (Kearney et al., 2012).

However, balancing control is very important for setting the appropriate learning goal and providing meaningful process and experience of learning in mobile environment. According to Sharples, Taylor and Vavoula (2005), the control and management of learning can be distributed across learners, guides, teachers, technologies and resources. The authors have mentioned that the control of learning may also pass between learners and technology, for example in a dialogue for computer-based instruction. More than that, the control can be passed between programs at the technological level as well as between people at the semiotic level (McAndrew, Taylor & Clow, 2007; Sharples, Taylor & Vavoula, 2007). They have explained that as the interactions between learning and technology are complex and varied, learners are opportunistically appropriating whatever technology is ready to hand as they move between settings.

According to Frohberg, Goth and Schwabe (2009), the optimal level of control may be distributed equally between teachers and learners. The authors have claimed that with full teacher control, the learners will become unmotivated and passive as well as not understanding what and why they are doing. On the other hand, with full learner control, they will possibly fail to perform meaningful activities, develop false conclusions, become frustrated and unsynchronized when in a group. As stated by the authors, each learner may need a different level of scaffolding and this need will decline over time as the learner can become able to act autonomously. In addition, this level ensures that each learner personally has enough guidance to be able to act and reflect on his own and to act in a coordinated way in a group level for interrelated activities.

Wong (2012) has viewed mobile learning as a personal control and ownership of the learning process for learners. The author has stated that placing the learners at the centre does not mean that they are the centre of attention of teachers, but rather the centre of production of knowledge that occurs in various contexts across spaces within their control. This setting allows the learners to be able to perform, and seamlessly switch between multiple learning activities, which may lead to knowledge synthesis. Perhaps, the learning outcomes of knowledge synthesis may be fed back to another round of learning activities that take place in the future. In addition to learning process, the ownership of mobile device, which integrates all the personal learning tools, resources and artefacts carried by learners all the times, enable the learners to manage and share the learning resources that they picked up along their journey to support a learning activity in the future (Sharples et al., 2007). Woodcock, Middleton and Nortcliffe (2012) have pointed out that learners are using their devices autonomously for learning by using some applications such as SMS, phone call, calculator, email, notepad, camera and video recorder. Recent study by Nerantzi and Beckingham (2014) has suggested that learners should have their own flexible device or tool to connect, communicate, collaborate, create and curate in their learning ecologies. Therefore, the ownership over learning is being identified as one of the critical success factors in implementing mobile learning projects (Naismith and Corlett, 2006).

Context

Mobile devices with camera and video capabilities enable situated learning or learning in context as it allows students to capture their own material and immediately transfer to other students and lecturers to support recall and reflection (Frohberg, 2004; Naismith, et al., 2004; Peters, 2007; Sharples, 2013). Context refers to the combined physical, information and social setting of learning, which for mobile learning in particular is in continual change (Taylor, et al., 2006). Context in mobile learning is a dynamic entity as it is constructed by the interactions between learners and their environment (Sharples, Taylor and Vavoula, 2005; Sharples, Taylor and Vavoula, 2007). Uden (2007) has pointed out that context is any piece of information which can be used to characterise the situation of a learner in an interaction and suggested to use activity theory in order to design contextual mobile learning environment. According to Liaw, Hatala and Huang (2010), context is an integral property of interaction and embraces multiple communities of actors who interact around a shared objective. A recent study (Herrington, Herrington and Mantei, 2009) has shown that authentic mobile context has personal meaning and relevance for learners which allow a deeper understanding to be achieved as it involves characteristics of collaboration, reflection and articulation in a learning environment. Importantly, a learner's cognition is defined and developed by its relation to a given context as in situated and constructivist learning (Uden, 2007). Economides (2008) has proposed a context model to include states of learner, educational activity, infrastructure and environment, which are further described by their dimensions. However, the proper dimensions and their corresponding variables remain an open research issue. As summarized by Klopfer and Squire (2008), learning context sensitivity means the ability to gather both real and simulated data unique to the current location, environment, and time.

According to Frohberg, Goth and Schwabe (2009), context can be classified into several categories, which are independent, formalized, physical and socializing based on the relationship between each context of learning with the context of being. The context could be labelled as independent if the learners' current environment has no relationship to their learning, as formalized if the learning occurs in a classroom-like setting, or as physical if the location is relevant for the learning issue. However, there has been an issue which is the focus problem faced by mobile learners when using mobile learning application in a physical context (Goth, Frohberg and Schwabe, 2006). Learners tend to interact with the devices, head down and ignoring the environment which leads to unachievable educational goals. For that reason, an optimal level must be found between the technology and the learning environment for designing effective application. Essentially, the highest rank of the classification is socializing context where the learners can have interpersonal relationship, emotions, friends, learning history, etc. This kind of context supports an informal community of learners to exchange and reflect on daily situations as well as act as peer coaches. Nevertheless, the authors have reported that no such research projects could perfectly fit this category. The classification of context discussed by them is shown in **Figure 5**.

As learning is very critically dependent on context, Winters and Price (2005) have defined different constructs of context relevant for learning. Context as historical/cultural/social perceives that learning could take place at different times in many different settings continuing throughout learners' daily life. The authors have divided context as location, into the current physical and social location of learners. According to Xia, et al. (2013), context may comprise information about the physical world, such as location and device characteristics and about the logical domain surrounding the learners such as relationships with friends, family and work. Meanwhile, context for activity means that interactions or tasks could be defined within a particular learning context which is influenced by learning goals or outcomes. On the other hand, context for usesr defines context based on learners' current understanding and skills, while context as content identifies relevant information for a specific learning domain. However, they have clearly acknowledged that these constructs of context are closely connected and highly interdependent.

Wong (2012) has argued that mobile learning should be seamless where the learners can learn in a variety of scenarios and in which they can switch from one context (e.g. formal and informal learning, personal and social learning) to another easily and quickly. This means that learners can learn whenever they are curious by using their own personal mobile devices to store, share and recall contextualized knowledge that will create an experience of continuity (Sharples, 2013). Wong (2012) has discussed ten features that support seamlessness in a mobile environment: encompassing formal and informal learning, encompassing personalised and social learning, learning across time, learning across locations, ubiquitous access to learning resources, encompassing physical and digital worlds, combined usage of multiple device types, rapid switching between learning tasks, knowledge synthesis and encompassing multiple pedagogical models. All the features are illustrated in the following **Figure 6**.

Communication

As mobile technology advancements allow fast communication, a new type of community of interest that does not depend on geographical proximity is created. This community consists of people for whom mobile communications are part of normal daily interaction and who are 'always on' or connected (Peters, 2007). Heng, Sangodiah and Ahmad (2012) have mentioned that in order to provide a better quality of teaching and learning for mobile environment, features that connect the learners to their learning community at any given time and location such as instant messaging must be provided as they enjoy that mechanism in interaction. The interactions do not only involve other people such as family, friends, colleagues, but also strangers and people from the media who are not directly involved in the learning (Vavoula, 2005). Based on US National Research Council 1999, effective learning

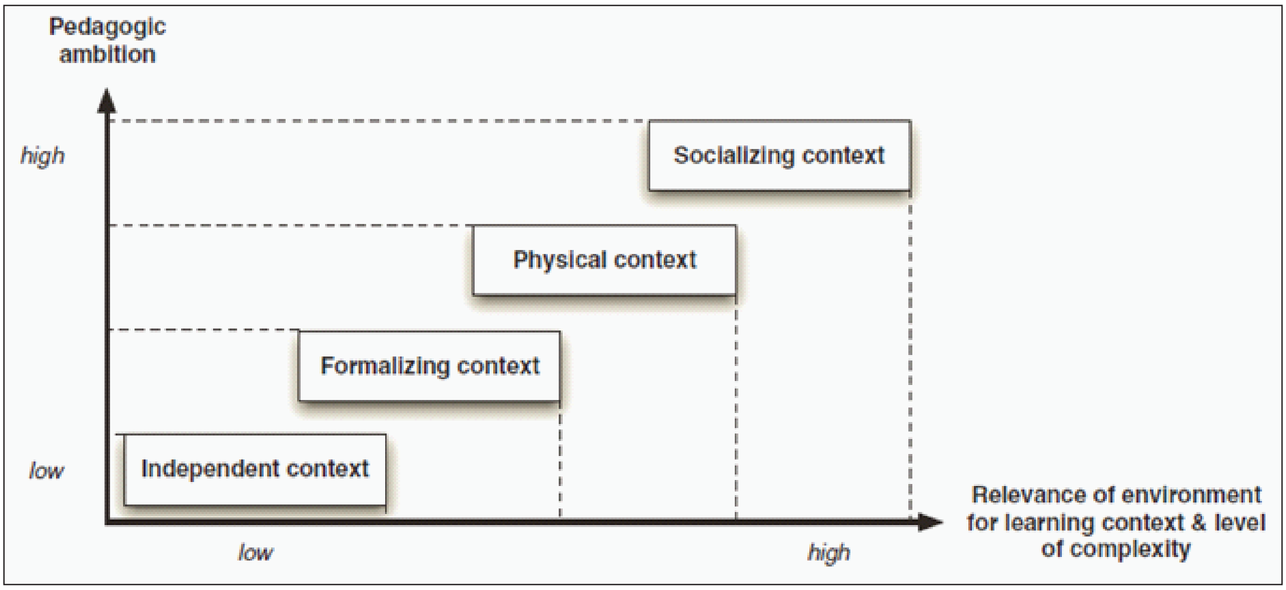

Figure 5: Classification of context (Frohberg, Goth and Schwabe, 2009).

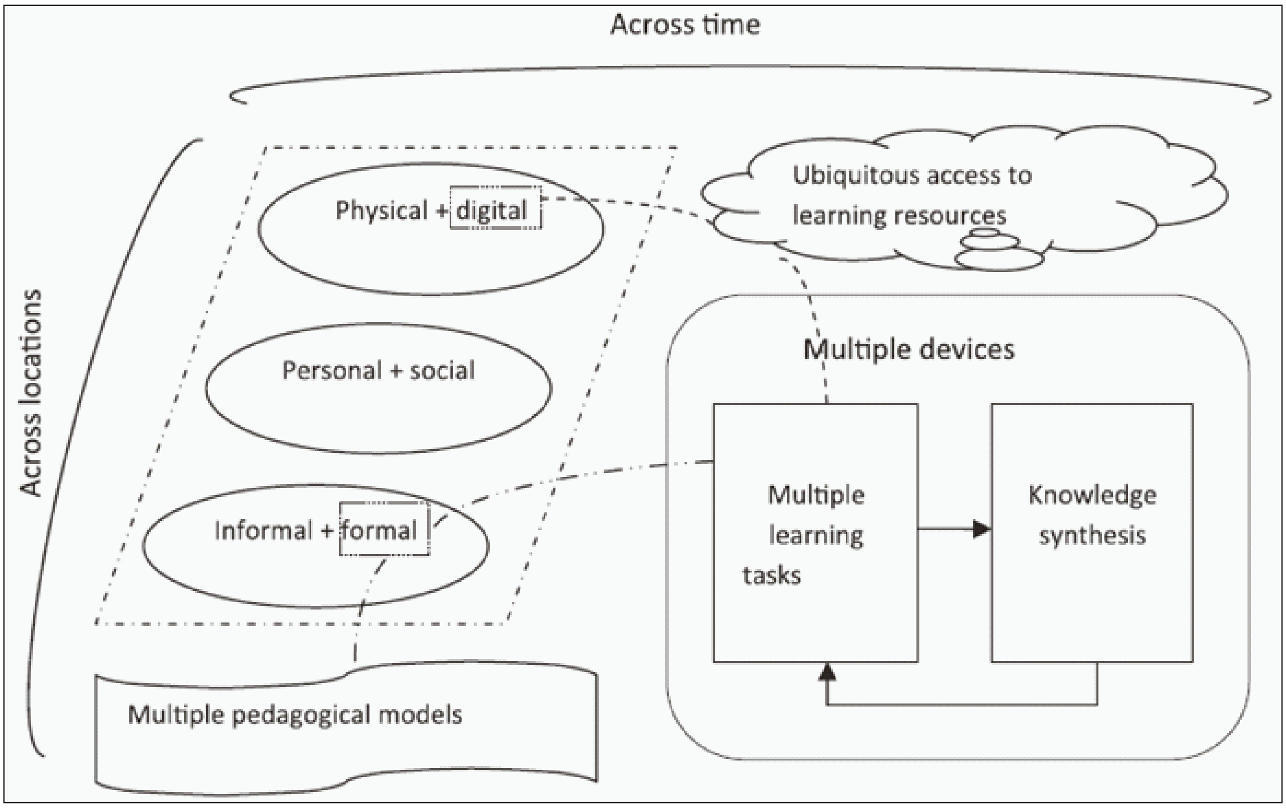

Figure 6: Features to support seamless learning (Wong, 2012).

must be community centred where successful learners are sharing knowledge and supporting less able students. This finding is supported by a social-constructive approach, which views learning as an active process of building knowledge and skills through practice within a supportive community whereby they can share information and artefacts with peers (Sharples, Taylor and Vavoula, 2005; Kearney et al., 2012).

Laurillard (2002) has demonstrated that mobile technologies may provide the environment for communication in which conversational learning takes place for a group of learners. Supported by Conversation Theory, Taylor, et al., (2006) have demonstrated that learning can be more successful when learners can converse with each other by formulating and sharing their descriptions of the world. They have emphasised that communication and collaboration lie at the heart of an effective pedagogy for mobile learning environments. As mentioned by Frohberg, Goth and Schwabe (2009), communication can lead to deeper knowledge as learners can discuss, analyse and work together with other learners on a specific learning activity to start intensive reflective process. In this way, they can help their team-mates and identify their own knowledge gaps to have better reflection and guidance in their learning and achieve the targeted learning goals. Given those reasons, mobile learning application must support various meaningful interaction and communication channels and technologies to provide diverse learning activities for learners either individually or collaboratively (Sharples, Taylor and Vavoula, 2007; Anani, Zhang and Li, 2008; Liaw, Hatala and Huang, 2010). According to Pachler, Cook and Bachmair (2010), communication could support the social interaction and process of meaning-making for learners. As indicated by Nouri, et al. (2010), allowing learners to use the communication capacity of a mobile device enables them to negotiate and adjust goals in collaborative learning activities.

Previous research studies (Frohberg, 2004; Motiwalla, 2007) have pointed out that mobile learning application should provide students with a chat forum or discussion tool as they seemed often to be willing to share their experiences and opinions with their teacher and peers. This tool could provide a platform for computer supported cooperative learning (CSCL) such as digital brainstorming, decision making and discussing complex questions to activate the students' thinking. Furthermore, learners are able to benefit significantly from the worldview diversity of their peers by engaging with other communities, despite geographical, cultural or socio-political isolation (Beckmann, 2010). Therefore, it must technically adopt the idea of service-based components to allow communication and information exchange with other systems such as social networks, apps and web services (Barbosa, 2013).

Ultimately, many studies (Taylor, et al., 2006; Botzer and Yerushalmy, 2007; Peters, 2007; Marston and Cornelius, 2010; Heng, Sangodiah and Ahmad, 2012) have demonstrated that the SMS text messaging with mobile phones is seen as an opportunity by a young generation of users to communicate with peers. This trend leads to the popularity of texting, which encourages the mobile phone designers to develop extra features to support it, such as predictive texting. Peters (2007) and Motiwalla (2007) have reported that SMS is a great motivational tool for young people because they can communicate with their peers and teachers flexibly as they can engage across physical space. SMS can be a platform to submit and respond to questions and if these are made available on the website as a resource to be viewed, learners can learn from exposure while conversations can further develop via comments (Sharples, 2013). A recent study by Udanor and Nwodoh (2010) on mobile learning model in Africa has shown the benefits of SMS for students, peers and educational institution. These findings have suggested that the mobile phone communication application could be used for group learning to collaborate with other learners in a specific task project to achieve specific learning goals.

Discussion

At the end of our systematic review, we have generated a table to summarize and interpret the evidence that we found. By reflecting on the synthesized information as presented in **Table 1** below, we are able to develop an understanding of each factor of the model and reason deeply to answer the research questions. All the requirements are labelled with the character(s) of what factor they are belong to. For example, S1 is for learning across spaces, times and topics by taking and applying ideas and resources.

For question 1 (What learning activities are performed and resources accessed by learners in mobile environment?), we summarize that learners are continually

Research question	Task model factor	Relevant pedagogical requirements	References
1. What learning activities are performed and resources accessed by learners in mobile environment?	Subject	Learn across spaces, times and topics by taking and applying ideas and resources (S1)	Sharples, Taylor and Vavoula, 2005; Edirisingha, Salmon and Nie, 2008; Economides, 2008.
		Capture data, create and share materials (S2)	Sharples et al., 2007; Botha, Herselman and Greunen, 2010; Sharples, 2013.
		Communicate, collaborate, annotate resources, personalise information and messaging, seamless access to services, resources and people (S3)	Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor et al., 2006; Botha, Herselman and Greunen, 2010.
		Access and capture multimedia contents (S4)	Xia et al., 2013.
		Perform rapid learning activities on the move (eg. photo taking, Internet search, map navigation) (S5)	Wong, 2012.
		Discussion, read, take note, search information, reflect, observe, solve problem and collaborate (S6)	Vavoula, 2005; Klopfer and Squire, 2008.
		Run experiments in the field study, capture, store and manage everyday events (S7)	Sharples, Corlett and Westmancott, 2002; Churchill, 2011.
		Collect and store data (S8)	Peters, 2007
		Converse and work together, compare conceptions and experiences, actively seek information and build up answer (S9)	Zurita and Nussbaum, 2004; Taylor et al., 2006; Beckmann, 2010.
	Object	Information, knowledge or learning resources (O1)	Taylor et al., 2006; Frohberg, Goth and Schwabe, 2009.
		Reusable, sustainable and scalable (O2)	Herrington, Herrington and Mantei, 2009; Barbosa, 2013.
		Online data and information, teacher-created materials, student artefacts and student's online interactions (O3)	Wong, 2012
		Audio recordings (eg. notes, feedback) (O4)	Nortcliffe and Middleton, 2008; Rossiter et al., 2009; Middleton, Nortcliffe and Owen, 2009
		Digital files and records, web-based and conversations content (O5)	Naismith et al., 2004; Vavoula, 2005; Sharples, Taylor and Vavoula, 2005.
		Micro-content which integrates text, image, video, audio and interactive elements (O6)	Bruck, Motiwalla and Foerster, 2012
		Multimedia resources (video, audio, voice recognition, image, web pages, notes, readings, podcast, vodcast, e-books, presentation) (O7)	Bacon, Windall and MacKinnon, 2011; Churchill, 2011; Heng, Sangodiah and Ahmad, 2012; Barbosa, 2013

(Contd.)

Research question	Task model factor	Relevant pedagogical requirements	References
2. How can control, context and communication support pedagogical needs in mobile environment?	Control	Access materials as and when convenient, work at own speed, revise and recheck them as they wish, able to test ideas, ask questions, collaborate, seek out new knowledge, plan new actions and control activity (CR1)	Taylor et al., 2006
		Manage learning pace and style (CR2)	Liaw, Hatala and Huang, 2010.
		Balance and optimal distribution between learner and teacher, act and reflect on activity (CR3)	Frohberg, Goth and Schwabe, 2009.
		Distributed across learners, guides, teachers, technologies and resources (CR4)	Sharples, Taylor and Vavoula, 2005; McAndrew, Taylor and Clow, 2007; Sharples, Taylor and Vavoula, 2007;
		Personal control and ownership of the learning, able to perform, and seamlessly switch between multiple learning activities (CR5)	Naismith and Corlett, 2006; Wong, 2012.
		Ownership of mobile device which integrates personal learning tools, resources and artefacts, use device autonomously (CR6)	Sharples et al., 2007; Woodcock, Middleton and Nortcliffe, 2012; Nerantzi and Beckingham, 2014.
	Context	Capture material and immediately transfer to others (CX1)	Frohberg, 2004; Naismith et al., 2004; Peters, 2007; Sharples, 2013.
		Constructed by the interactions between learner and environment (CX2)	Sharples, Taylor and Vavoula, 2005; Sharples, Taylor and Vavoula, 2007; Uden, 2007
		Multiple communities of actors who interact around a shared objective (CX3)	Liaw, Hatala and Huang, 2010.
		Personal meaning and relevance for learners (CX4)	Uden, 2007; Herrington, Herrington and Mantei, 2009.
		Ability to gather data unique to the current location, environment, and time (CX5)	Klopfer and Squire 2008
		Independent, formalized, physical and socializing (CX6)	Frohberg, Goth and Schwabe, 2009
		Constructs as historical/cultural/social, location, activity, user and content (CX7)	Winters and Price, 2005
		Seamlessness in learning in a variety of scenarios and switching from one context to another easily and quickly (CX8)	Wong, 2012; Sharples, 2013.
	Communication	Connect the learners to their learning community at any given time and location (CM1)	Peters, 2007; Heng, Sangodiah and Ahmad, 2012
		Community centred for sharing knowledge and supporting less able students (CM2)	Sharples, Taylor and Vavoula, 2005; Kearney et al., 2012
		Converse with each other (CM3)	Laurillard, 2002, Taylor et al., 2006
		Discuss, analyse and work together with other learners (CM4)	Frohberg, Goth and Schwabe, 2009.
		Support various meaningful interaction and communication channels (CM5)	Sharples, Taylor and Vavoula, 2007; Anani, Zhang and Li, 2008; Liaw, Hatala and Huang, 2010; Nouri et al., 2010; Pachler, Cook and Bachmair, 2010.
		Chat forum and discussion tool for brainstorming, decision making and discussing complex questions (CM6)	Frohberg, 2004; Motiwalla, 2007
		Engaging with different communities (CM7)	Beckmann, 2010.
		Service-based components (CM8)	Barbosa, 2013.
		SMS (CM9)	Taylor et al., 2006; Botzer and Yerushalmy, 2007; Motiwalla, 2007; Peters, 2007; Marston and Cornelius, 2010; Udanor and Nwodoh, 2010; Heng, Sangodiah and Ahmad, 2012; Sharples, 2013

Table 1: List of relevant pedagogical requirements identified for each factor based on the research questions.

collecting and storing data, information or files across locations, times and topics to support their learning process such as preparation and reflection. They are also performing learning activities on the move such as listening to audio files, surfing the web and participating in online discussion. Moreover, they are collaboratively working together in constructing knowledge and solving problems to achieve specific learning goals. The resources are accessed by them normally in the form of online data and information or reusable digital text, image, audio and video files created and shared either by their teachers or peers.

For question 2 (How can control, context and communication support pedagogical needs for mobile environment?), we conclude that learners need to be provided with a balanced and optimal level of control for managing their learning processes effectively. They must be able to access materials conveniently, and switch between multiple learning activities. Ultimately, the learning activity must take place in a contextualized environment to capture relevant and meaningful resources and interaction which are very essential to their experiences. In addition, good communication methods and channels ensure pleasant support for knowledge sharing and activity collaboration by providing them a platform to connect, share, converse, interact and discuss in the activities.

Based on the understanding that we have gained through the above review, we have designed a techno-pedagogical tool to support learner activities in mobile environment. We have named it as MOBIlearn2 version 1.0 in accordance with the name of MOBIlearn project that produced the Task Model framework. It has been developed by using App Inventor version 2.0 which is originally provided by Google and now maintained by the Massachusetts Institute of Technology (MIT). App Inventor contains built-in components that provide functionalities and services for Android mobile devices. Once the

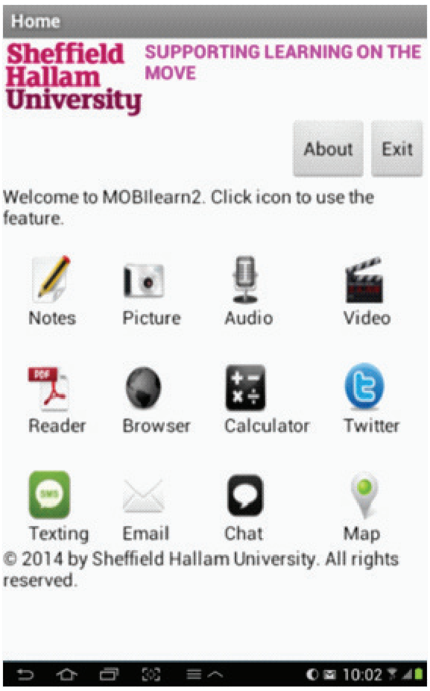

Figure 7: Main interface of MOBIlearn2 v1.0.

MOBIlearn2 v1.0 development is completed, it is packaged in .apk file and can be distributed to learners' devices as a stand-alone application. **Figure 7** shows the main interface of MOBIlearn2 v1.0.

All of the components and their functionalities in the MOBIlearn2 v1.0 are described in **Table 2** below. **Table 2** also relates all the pedagogical requirements labelled in **Table 1** to each of the components of the tool that supports them.

From the table, we also can see that the combination of MOBIlearn2 v1.0 components can support all of the requirements for each of the factors. By using this tool, the learners can perform their personal learning activities in anytime, anyplace and as they wish. Moreover, they can interact as well as contribute and exchange materials with their peers or teachers in social learning. We therefore recommend this tool as we believe that it can provide a pleasant and rich learning experience for learners either in a formal or an informal mobile setting.

Conclusion and future works

From this review, we have found that the MOBIlearn task model framework is very significant for mobile learning designers in order to understand pedagogical requirements for mobile learning to support educational purposes. By systematically investigating the task model, we are able to generalize our current state of understanding and discover common ground and similarities related to its factors detailed earlier published research studies. These factors need to be considered properly in an effort to support mobile learners' activities, communications and collaborations with a view to enhance their learning experiences in the mobile environment. This study has therefore demonstrated the usefulness of the task model framework for the purpose of understanding the pedagogical needs in the mobile educational setting.

We have also found that designing a techno-pedagogical tool to support pedagogical learning activities for higher education students is a very challenging process. Despite the outcome of this review being very clear, the proposed tool has been designed with a set of mobile applications in order to enhance the whole learning experience for students. From this design, we have learned that there is no single mobile application or component that can fulfill pedagogical needs, but rather a variety of tools and a variety of uses for any single tool as well. For example, the camera tool of the mobile device can capture contextual learning data and moment but the data needs to be shared through a network among the learners and lecturer in order to be reflected upon effectively and that camera function is needed when the learners need to record a video for their learning. Moreover, the proposed tool can be enhanced using a cross-platform development technique so that it can be customized based on the needs of a specific individual or learning activity.

From our point of view, there are several challenges that need to be considered such as ethical, security and infrastructure issues in order to implement mobile learning at a scale, beyond pilots and content-centric approaches. Texting and surfing the internet in the classroom can be

Component	Functionalities	Requirements supported
Note	Learner can write and save notes into txt files. The notes can be opened for reading or editing as well as shared with peers.	S1, S2, S6, O1, O2, O5, CR1, CR2, CR6
Picture	Learner can take a new picture, pick a saved picture from gallery as well as share it with others.	S1, S2, S5, S7, S8, O1, O2, O6, O7, CR5, CR6, CX1, CX2, CX4, CX5, CX7, CX8
Audio	Learner can record, play, share and delete audio files. The recorded files will be displayed in a list which the latest file is on top.	S1, S2, S3, S4, S7, S8, O1, O2, O4, O6, O7, CR1, CR2, CR5, CR6, CX1, CX4, CX5, CX7, CX8
Video	Learner can capture, play, share and delete video files. The recorded videos will be displayed in a list which the latest file is on top.	S1, S2, S4, S5, S7, S8, O1, O2, O3, O6, O7, CR1, CR2, CR3, CR5, CR6, CX1, CX2, CX4, CX5, CX7, CX8
Reader	Learner can open and read pdf files.	S6, O1, O5, O6, O7, CR1, CR2, CR4, CR5, CR6, CX6
Browser	This component act as a browser. Learner can surf or access a web page by typing the keyword in the search textbox.	S1, S4, S5, O3, O5, O6, O7, CR4, CR6, CX6, CM6, CM8
Calculator	This component works as a standard calculator.	S5, CR5, CR6, CX4, CX8
Twitter	This twitter client allows learner to post and share their thoughts with communities of interest.	S1, S3, S4, S6, S9, O3, O5, O6, O7, CR1, CR3, CR4, CX3, CX4, CX6, CX7, CM1, CM2, CM3, CM4, CM5, CM6, CM7
Texting	Learner can type a message and send it to the other learners individually or by group. The learner can add or remove a member's contact number. All members are displayed in a list.	S1, S3, S6, S9, O5, CR1, CR6, CX4, CX6, CM1, CM3, CM4, CM5, CM6, CM9
Email	Learner can write email with attachment to peers.	S3, CR1, CR6, CX3, CX4, CX6, CM4, CM5, CM6, CM7
Chat	Two learners can establish a real-time chat session whereby one of them is acting as a server and the other is a client.	S3, S6, S9, O5, CR1, CR6, CX4, CX6, CM3, CM4, CM5, CM6
Map	Learners can navigate within a location by using this component. They also can save the location that is interesting to them for future use.	S5, O1, O2, O6, CR4, CR6, CX2, CX4, CX5, CX7, CM8

Table 2: Components in the MOBIlearn2 v1.0.

seen as disruptive by some lecturers. The students also can cheat during exams if they can access information at that time. In terms of security, the photo or video taken by learners can be manipulated to serve bad purposes. By the way, the need for better infrastructure such as reliable Wi-Fi connection especially in the university and mobile data network is very critical. As students need to upload and download learning materials from and to their mobile devices, this network connection issue must be resolved in an effort to provide the learners with good experiences.

Nevertheless, the study must not stop here. In our view, all these requirements must be tested and validated through the MOBIlearn2 v1.0 prototype in future case studies where the real users will be in control of their learning process and in real mobile learning context as well as involved in communication among them to achieve specific learning objectives. This is to get feedback and acceptance from the learners in order to ensure that the tool really supports them for learning on the move. Furthermore, any future studies hopefully will reveal more complete or new requirements that will help to refine the design of MOBIlearn2 v1.0 in enhancing mobile learning experience. For future work, we intend to set up case studies to evaluate the identified pedagogical requirements against the functionalities of our tool.

Competing Interests
The authors declare that they have no competing interests.

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