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Collaborative and ubiquitous mobile learning system prototype

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Abstract: Mobile learning applications utilise the advantages of mobile technologies to increase learning opportunities, mainly on an anytime, anywhere basis. The advancement of mobile technology has facilitated the development of numerous applications to improve students' learning experience and performance. Successful implementation of m-learning is highly dependent on learning context and environment awareness. This work presents a multiphase exploration of early phases responsible for defining and validating the m-learning context, and later phases based on context validation results achieved from the previous phases, involving the development and evaluation of a new m-learning context prototype. This new prototype proved to provide context-aware and ubiquitous learning services fulfilling several diverse user interaction levels and requirements.

Keywords: mobile learning; m-learning; m-learning system; e-learning; context factors; ubiquitous learning; collaborative learning; mobile learning system prototype; learning context; context aware ubiquitous learning.

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1 Introduction

Since the late 1990s mobile phones have emerged as a fundamental technological product and the rapid commercially driven advancement of mobile technologies, particularly the advent of computing via smartphones since the 2000s, has resulted in an explosion of innumerable new mobile products and applications for task solutions, including learning tools to improve learners' knowledge, skills and learning experience. Mobile learning (m-learning) applications utilise the advantages of mobile technologies to increase learning opportunities regardless of users' location. Mobile and wireless connections facilitate users' interaction and information access anytime, anywhere supporting ubiquitous and ambient learning activities. Successful implementation of m-learning is highly dependent on learning context and environment awareness. Learning context can be described as any information related to learners' requirements, mobile device and network capabilities, and surrounding environment parameters. Technical capabilities explain specifications of users' mobile device and communication networks.

Users' requirements consist of two main parameters; learning style, used to identify interaction between learning service activity and users, and used to define appropriate learning resources; and user type, which describes users' constraints and explains the sensitivity of learning services (Alnabhan and Aljaraideh, 2014). These contextual factors are considered as determinants influencing successful implementation and adoption of m-learning systems. For example, understanding learning style is a key factor to consider when implementing collaborative m-learning systems involving multiple users. Accordingly, context adaptation should be included within m-learning applications design and development phases to efficiently refine the usability of mobile technology and anticipate users' needs. This allows technologies to proactively provide appropriate and customised learning content and services to users.

Several researchers have addressed context-awareness in m-learning applications (such as, Wang and Wu, 2011; Alnabhan, 2014; Alnabhan and Aljaraideh, 2014). In addition, context adoption has been wildly utilised in Augmented Reality (AR) technology for providing more accurate information about surrounding objects for robust tracking and communication system (Bajana et al., 2016). Context of human body has also been applied in gaming applications to measure corresponding hand motions for enhanced user experience (Han et al., 2016).

Accordingly, several research studies have investigated the understanding of contextual environment to develop useful and adaptive applications. Context adaptation has been considered to develop users' experience in m-learning applications. However, some user groups with special needs and within difficult technological settings continue to face various barriers in learning service accessibility and adoption. In addition, successful adaptation while learning content construction and provision is a continuous and challenging task. The deployment of inappropriate m-learning solutions relative to user needs can comprise a counterproductive barrier to educational access, while novel barriers have also emerged in some areas of m-learning context adaptation and development. Hence, a new method of context adaption needs to be addressed allowing for the development of interrogated systems that fulfils most users' requirements.

This work presents a new m-learning model achieving a set of unified advantages over models reported in previous research work such as ubiquity and collaborative content access, increased learning users' interaction, context-awareness and personalised learning service. To achieve this aim, the study seeks to achieve three objectives, to:

- Describe the m-learning contextual environment by using extensive literature survey and quantitative studies focused on mobile users' requirements, technical capabilities and learning resources attributes.
- Present an integrated m-learning system model implemented based on context description from the previous step. This model provides different learning service levels and interactions. A prototype of this proposed model was developed for evaluation purposes.
- Evaluate the performance of the developed prototype using real-time experimental scenarios and quantitative studies. This step measures the successful implementation of the proposed model, context adaptation and service interaction.

The following sections present the literature and related work, while Section 3 presents the research design. Section 4 investigates outcomes and results achieved from each research phase and Section 5 concludes this work.

2 Literature review

The rapid development of ubiquitous computing, wireless networking and broadband internet has expanded anytime, anywhere e-learning availability, resulting in a large body of research on using mobile and wireless communication technologies (Chu et al., 2010; Hwang and Tsai, 2011), including specific applications such as the use of m-learning in nursing activities to design context-aware mobile learning systems for nursing training courses (Guo et al., 2007;

Wu et al., 2012), and the use of mobile technology to support English teaching and learning (Cavus and Ibrahim, 2009; Chang and Hsu, 2011; Hsu et al., 2013). In this paper, related work is divided into three categories: (1) context aware ubiquitous learning system; (2) collaborative m-learning; and (3) m-learning with special focus on m-learning acceptance.

Ubiquitous learning system is highly dependent on mobile devices (i.e., smart phones, which are used and useful due to their physical properties (i.e., portability), attractive interface and online capabilities (Wang and Wu, 2011). Use of smart phones provides learners with a dynamic environment in which they can access course resources related to their practical context, communicate and engage in learning activities without locative constraints (Wang and Wu, 2011; Yu et al., 2015). This essentially pertains to ubiquitous learning (u-learning), which studies (Yu, 2007; Hwang et al., 2009; Wong and Looi, 2011) indicate differ from traditional learning in its anytime, anywhere accessibility, personalisation, superior embedding in daily-life learning and its more socialised format. It should be emphasised that u-learning does not merely mean providing learners with learning resources anytime, anywhere; it also means providing them with suitable learning assistance according to their contexts and learning needs, assisting them to accomplish their e-learning tasks (Wang and Wu, 2011).

Hsu et al. (2016) designed an Active Learning Support System (ALESS) for context-aware ubiquitous learning environments that aims to provide learners with extra real-time supports. The evaluation of the developed system was conducted by using a learning activity belonging to a unit in an elementary school natural science course in Taiwan National Museum of Natural Science. The results revealed that ALESS improved students' learning efficiency and increased learner performance, especially when there was insufficient time to finish the learning tasks. Liu et al. (2016) investigated the sources of learning effectiveness that can be identified in u-learning. The researchers designed an appropriate learning model for u-learning to enhance the effectiveness of overall learning by utilising personalised learning features, strategy-driven learning design, learner memory, learning achievement in a u-learning setting and learner motivation in u-learning. They recommended the development of multiple learning dimensions, including collaborative and inquiry-based learning, in order to engage learners in more interesting and effective learning environments.

Collaboration is a main concern in learning context. Learners connect and collaborate together and with their tutor to complete the learning process and increase learning performance (Abu-Al-Aish et al., 2013). Collaborative learning describes the learning process by focusing on a student-centred environment, to enhance the interactive relationship between lecturers and students (Xu et al., 2015). Collaborative learning has played an increasingly significant role in education software, especially in m-learning applications. It is useful within complex and multi-faceted educational processes, enhancing student progress to improve the learning situation as students can work together when learning and solving problems (Troussas et al., 2014). Collaborative learning is considered an important aspect in designing and developing m-learning prototype. Troussas et al. (2014) proposed a student-oriented approach to support collaborative language learning between students by using mobile phones, and they developed a prototype mobile application for multiple languages learning that comprise intelligence in its analytical components.

DeWitt et al. (2014) investigated whether a collaborative mobile learning prototype can be utilised as an interaction and learning tool in secondary school science studies. The results revealed that interaction by using collaborative mobile learning prototype can allow the language of science to be modelled for knowledge-building and increase interaction in learning. Collaborative learning is usually integrated into the u-learning context, through identifying the individual geographical and learning situation specific requirements is necessary for optimum outcomes, with context-aware learning support being a necessary prerequisite of u-learning tools (Liu et al., 2016).

In order to achieve ubiquitous, collaborative and context-aware learning, it is important to identify the factors in learner acceptance of m-learning, to which end many studies have concentrated on student perceptions of mobile learning, the learning context involved and the types of interactions used to enhance the outcomes measured (Abu-Al-Aish et al., 2013; Al Zahrani and Kumar, 2015). Abu-Al-Aish and Love (2013) investigate factors influencing university students' intention to accept m-learning utilising a model based on the Unified Theory of Acceptance and Use of Technology (UTAUT) with an additional two factors, quality of service and personal innovativeness. The outcomes indicated that performance expectancy, ease of use, impact of lecturers, quality of services were all significant factors that affect behavioural intention to use m-learning. Alnabhan and Aljaraideh (2014) investigated the acceptance and readiness of university students towards adopting m-learning services focused on contextual factors and learning requirements in developing countries such as Jordan. The results indicated that mobile device capability and learning styles have the most significant contribution to behavioural and intention to use collaborative m-learning services. Similarly, Chung et al. (2015) identified mobile device compatibility, self-efficacy and perceived ease of use as having a high positive correlation with students' behavioural intention to use m-learning, based on their investigation of factors affecting Taiwanese EFL (English as a Foreign Language) college students' behavioural intention to use English vocabulary learning resources by using the Technology Acceptance Model (TAM).

An increased number of research studies have used these contextual factors and acceptance evaluation for proposing and developing new m-learning system prototypes. Alzaza and Yaakub (2011) developed a Students' Mobile Information Prototype (SMIP) to ease students' learning in a higher education environment. An evaluation work was carried out in order to measure users' perception on the usability of SMIP. The results showed that students highly agreed on perceived usefulness, perceived ease of use, learnability, functionality and didactic efficiency. Hsu et al. (2013) presented a personalised based m-learning method supporting EFL students in their studies. The proposed approach evaluated effectiveness by dividing three classes of students into two experimental groups and one control group. The TAM terms including perceived ease of use, perceived usefulness and perceived satisfaction were implemented to analysis the learning achievements. In addition, Alnabhan (2014) utilised m-learning contextual factors to develop a collaborative and ubiquitous m-learning system aiming to provide location-based learning services to users based on their learning styles and positional information. The system evaluation confirmed its successful implementation and capability to provide context-aware m-learning services.

Accordingly, several research studies have investigated m-learning contextual factors and technology acceptance behind the usefulness and adoption of these m-learning systems, but there is still great need for detailed contextual description, encompassing technological factors, user requirements and preferences and learning content characteristics. In addition, this integrated and extensive context description needs to be addressed in a new unified m-learning system that fulfils all users' requirements.

3 Research design

In this research, the mixed-method approach was undertaken. In addition to quantitative and qualitative approaches, mixed-methods approach is becoming the third major research paradigm, (Johnson et al., 2007). Mixed-methods studies are "those that combine the qualitative and quantitative approaches into the research methodology of a single study or a multiphase study". (Tashakkori and Teddlie, 1998).

This research work was conducted based on a multiphase research approach, as shown in Figure 1.

- *Research phase 1:* It defines m-learning context variables through an extensive systematic and analytical literature review to identify the main factors and variables describing the m-learning context.
- *Research phase 2:* It validates the results achieved from phase 1, and defines current m-learning students' context through a quantitative questionnaire designed based on context variables identified from phase 1.
- *Research phase 3:* It presents the proposed m-learning system prototype. A learning tool was designed and developed based on outcomes of phases 1 and 2, in order to implement the proposed prototype and achieve context-aware and adaptive learning services.
- *Research phase 4:* It evaluates the successful implementation of the proposed m-learning prototype by using a set of experimental scenarios, followed by a quantitative study measuring level of acceptance and usefulness.

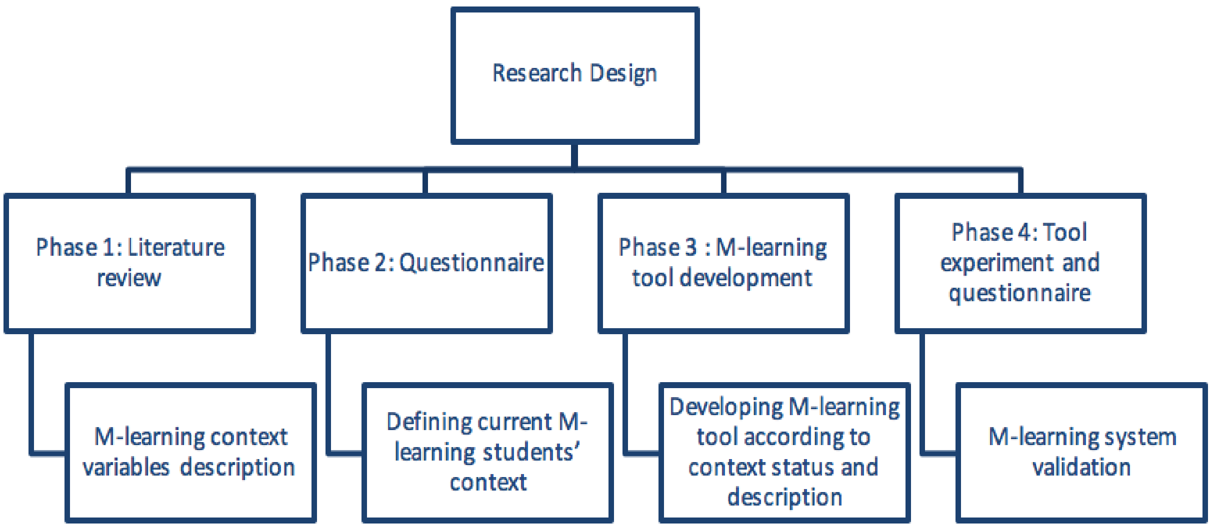
Bryman (2012) lists many ways of combining quantitative and qualitative research such as:

- By using qualitative research to inform the design for survey questions (Instrument design).
- Testing hypothesis generated be qualitative research by using quantitative research (Confirm and discover).

In this research, literature review (qualitative) was employed to develop questionnaire variables in phase 2 (instrument design) and a questionnaire followed phase 3 to test and validate results from phase 3 (confirm and discover).

Accordingly, four integrated research phases were conducted, each of which is dependent on the results and outcomes achieved from the previous one. This process has allowed the development of a context-aware, adaptive and collaborative m-learning system.

Figure 1 Research design



4 Results and discussion

This section shows the results obtained from all research phases.

4.1 Research phase 1: context description

An intensive review of literature pertinent to m-learning context research revealed three main factors required for accurate context description: technical capabilities, user requirements and learning content characteristics (Table 1).

As explained in Table 1, context factors are associated with several concerned areas and measurement variables describing the context environment, features and required threshold levels. Technical capability is the first main context factor that has three concerned areas: network performance, mobile device features and positioning technology ability. User requirements are concerned with: user learning styles, user capability and user collaboration type. The last factor is the learning content characteristics, which consist of two concerned areas: content format and content interactivity level. All these factors and variables are used to uniquely describe the m-learning context and are validated in the next section.

4.2 Research phase 2: defining the current m-learning students' context

Context description achieved through literature as described in phase 1 was validated to define most effective and up-to-date and related context factors by using a questionnaire distributed to 51 students to define m-learning environment. After initial survey, it was confirmed that the first context factor (technical requirements) was not amenable to being surveyed because most of the students were not aware of their phones' technical capabilities. However, two other context factors were deeply surveyed: user requirements and learning content characteristics.

Tables 2, 3 and 4 show student responses regarding user requirements; each table represents a different concerned area. Table 2 describes user-learning collaboration through different interactivity scenarios. 51% of participants prefer active learning within groups of matching peers.

Table 1 M-learning context description

Concerned area	*Measurement variables*	*Values and threshold description*
Technical capabilities		
Network performance (Almasri et al., 2009)	• Connectivity type • Connectivity range	• 3G, 3.5G, 4G, Wi-Fi • LAN, WAN
Mobile device features (Almasri et al., 2009; Bahamóndez and Schmidt, 2011)	• Screen size and resolution • Memory size • Operating system • Processing power	• 3.5" 640 × 360, 3.7" 480 × 854, 4.0" 480 × 800, 4.3" 480 × 800, 4.8" 720 × 1280, 5.7" 2560 x 1440 • 256 MB, 512 MB, 1 GB, 2 GB • iOS, Android, Windows Phone, BlackBerry, Symbian • 1.9 GHz quad-core, 1.4 GHz quad-core, 1.4 GHz dual-core, 1.5 GHz, 1 GHz, 680 MHz,
Positioning device ability (Alnabhan et al., 2010; Alnabhan et al., 2017)	• Accuracy • Operational area	• < 2 meters, > 2 meters • Open space areas, obstructed areas
	User requirements	
User learning style (Felder and Brent, 2005)	• Active, reflective • Visual, verbal	• Perceptiveness • Interaction • Responsiveness • Behaviour
User capability (Roberts, 2013; Alnabhan et al., 2014)	• Special needed user • General user	• Dyslexic, visual impaired, deaf • No learning difficulties
User learning collaboration type (Alnabhan and Aljaraideh, 2014)	• Passive learning • Peer-to-peer learning • Group learning	• Reading materials offline • Active learning with one peer • Active learning with group of matching peers
	Learning content characteristics	
Content format (Hassan et al., 2012)	• Standard content • Rich content	• Textual • Graphical, audio/video, animated
Content interactivity (Choil and Kang, 2012; Alnabhan and Aljaraideh, 2014)	• Low level interaction: • High level interaction:	• Case studies and problem solving • Educational games, location-based learning, group projects

Table 2 User learning collaboration type

Interactivity scenario	*Frequency*	*Percent (%)*	*Valid %*	*Cumulative %*
Reading materials offline	7	13.7	13.7	13.7
Active learning with one peer	18	35.3	35.3	49.0
Active learning with group of matching peers	26	51.0	51.0	100.0
Total	51	100.0	100.0	

Table 3 User learning styles

Learning style examples	*Frequency*	*Percent (%)*	*Valid %*	*Cumulative %*
Using pictures, images colours, and maps to unify information and connect with others (visual learner)	35	68.6	68.6	68.6
Using words both in speech and writing (verbal learner)	16	31.4	31.4	100.0
Total	51	100.0	100.0	

Table 4 User learning difficulties

Learning difficulty example	*Answer*	*Frequency*	*Percent (%)*	*Valid %*	*Cumulative %*
Do you have any learning difficulties? (e.g., visually or hearing impaired)	Yes	1	2.0	2.0	2.0
	No	50	98.0	98.0	100.0
	Total	51	100.0	100.0	

When participants were asked about their preferred learning style, results show that 68.6% of participants are visual learners, prefer using images, pictures and maps to manage information and communicate with each other, as illustrated in Table 3.

Users' capabilities and special requirements are illustrated in Table 4, where it can be seen that 98% of participants did not report any learning difficulties.

The last context factor validated through the survey was learning content characteristics. This includes two main areas: content format and content interactivity level, as illustrated in Tables 5 and 6, respectively. Regarding the preferred content format, results show that the majority (90.2 %) of participants prefer rich content (text, graphical, audio/video, and animation), as shown in Table 5.

Table 5 Preferred learning content format

Content formats	*Frequency*	*Percent (%)*	*Valid %*	*Cumulative %*
Standard content(textual)	5	9.8	9.8	9.8
Rich content (text, graphical, audio/video, animation)	46	90.2	90.2	100.0
Total	51	100.0	100.0	

However, the results shown in Table 6 indicate that 74.5% of participants prefer high level interaction, such as using location-based learning and group projects.

Table 6 Learning content interactivity

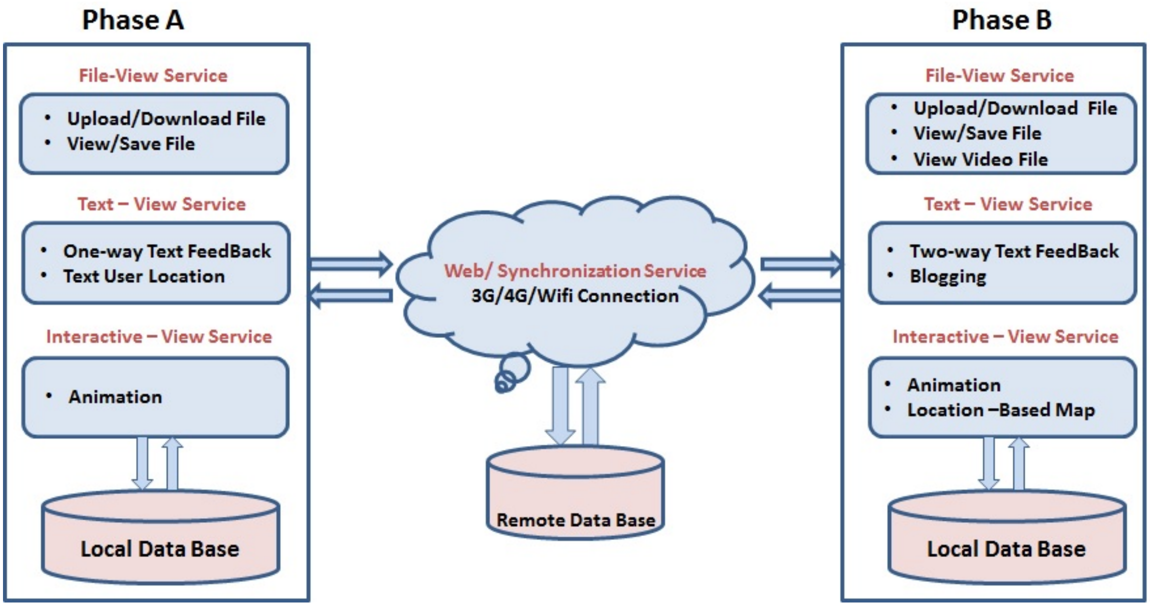
Interactivity levels	*Frequency*	*Percent (%)*	*Valid %*	*Cumulative %*
Low level interaction (e.g., case studies, problem solving)	13	25.5	25.5	25.5
High level interaction (e.g., location-based learning, group projects)	38	74.5	74.5	100.0
Total	51	100.0	100.0	

Validation of context factors and variables has identified a variety of learning users' requirements and several learning environmental conditions. Evidently different learning styles and collaboration types exist, but more users tend to be visual and group learners. Furthermore, learning resources can be available in different formats providing several levels of interactivity. However, it was clear that more students prefer rich and highly interactive learning formats. Therefore, this has motivated the need to design and develop an integrated and adaptive m-learning system that takes into consideration context factors and associated concerned areas and variables. Research phase 3 describes the proposed m-learning system prototype.

4.3 Research phase 3: proposed m-learning prototype

This section describes the proposed m-learning system prototype components, architecture, operational phases and underlying technologies. A simple m-learning tool was developed to implement the proposed prototype. Figure 2 shows the conceptual model of the m-learning tool. The proposed prototype consists mainly of two operational phases based on the capability of the mobile device, user requirements and learning content characteristics. These phases provide a set of m-learning services, ranging from static, passive and offline services to real-time, rich and collaborative services.

Figure 2 Proposed m-learning tool conceptual model

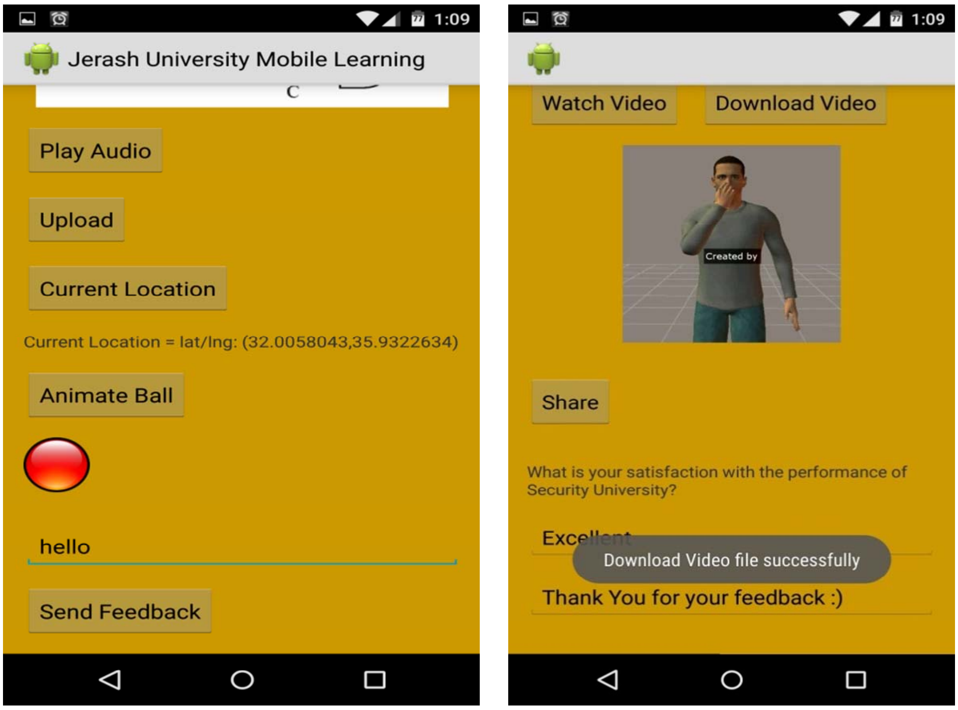


Both operational phases provide three types of learning services, including *File-View Service, Text-View Service* and *Interactive-View Services*. These services were obtained based on the context factors investigated and analysed in Section (4.2).

Phase A and Phase B provide different sets of subservices to m-learners. Phase A focuses on static services suitable for limited mobile capabilities and for passive learners incurring standard and low interactive learning resources. Phase A components include *file-view* services which provides several file functions such as save, view, upload and download; the second service is *text-view* which allows one-way feedback and text user location display; the last service is *interactive-view* which provides animation features for users. On the other hand, Phase B provides dynamic services for high-end mobile devices and for active group learners incurring rich and highly interactive learning resources. Phase B *file-view* service adds an extra feature which include video files streaming; *text-view* service allows for two-way feedback connection and blogging; *interactive-view* service displays users' location on a map comparing to text display in Phase A.

This design allows for interoperability and integration between m-learners and learning services. A local data base is used to provide information feeds and updates to these learning services. Also, some services inquire information and data from remote database through the web and synchronisation services accessed via mobile connectivity.

Figure 3 Snapshots of services in Phase A (left) and Phase B (left)



Generally, this m-learning tool was designed to be implemented on the smart phone. The underlying technology used in this application was based on the following:

- Basically, the proposed tool was developed on Android platform by using Java programming language. Android is an open-source mobile operating system and application framework based on Linux Kernal. Android offers developers the ability to build innovative applications with rich and dynamic interfaces, and support a wide range of content formats. Android platform is supported with Java programming language for application utilities and capabilities.
- Mobile and wireless networks supporting e-learning services' synchronisation and remote information accessibility for m-learners. This includes 3G and its later 3G releases, often denoted 3.5G and 3.75G, and the latest 4G standard to provide mobile broadband access to smart phones and other mobile devices.

Figure 3 shows snapshots of Phase A and Phase B learning services during implementation and running.

Phase A snapshot describes features that can be utilised such as upload and download files, static text display and simple animations. On the other hand, Phase B snapshot includes more dynamic and advanced features such as streaming video clips, downloading video files, map navigation and interactive feedback service.

4.4 Research phase 4: proposed m-learning prototype evaluation

Evaluating the proposed m-learning prototype consists of two main parts. The first part measures the successful implementation of the prototype. This was basically achieved from the tool development and implementation described in the previous step. The second evaluation part involves exploring students' perceptions of learning and engagement that occurs as result of using the proposed m-learning prototype. This was conducted by asking the same participants from phase 2 to fill a questionnaire to capture their feedback, after they tried both Phases (A and B) of the developed m-learning tool.

Phases A and B were evaluated by using a set of constructs to measure mobile users' perceptions and interaction toward by using these phases. These constructs are perceived usefulness (5 items), perceived ease of use (6 items) and behavioural intention of use (4 items) adopted from TAM. An additional two variables were added to investigate students' acceptance in a specific learning context and the extent to which they were engaged in this technology: perceived learning (5 items) and perceived engagement (5 items).

Perceived ease of use and perceived usefulness by using m-learning system refer to students' belief that m-learning is easy to operate and enhances their learning performance, respectively. The construct perceived learning examines how m-learning would benefit students in their learning activates, while perceived engagement refers to the extent to which students take part in educationally effective practices. *Behavioural intention to use* m-learning describes a person's subjective probability that he or she will perform m-learning.

Perceived usefulness, perceived ease of use and behavioural intention to use originate from the questionnaire developed by Davis (1989), whereas perceived learning and perceived engagement are oriented from Rossing et al. (2012). By using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree, students were asked to indicate the extent to which they agreed or disagrees with the given statements.

A total number of 51 students from the Faculty of Information Technology at Jerash University participated in this study. All of the participants came from Information Technology subjects (i.e., Computer Science, Computer Information Systems and Computer Networks), comprising 54.9% males and 45.1% females, aged 19–27. All participants have internet access on their mobile devices, 90.2% of participants declared that they utilised m-learning in their studies.

Cronbach's alpha (Cα) test was conducted in order to assess the reliability of the measured data. A Cα less than 0.60 is considered poor reliability; between 0.60 and 0.70 is minimally suitable; between 0.70 and 0.80 is admired; and between 0.80 and 0.90 is great (De Vellis, 2003; Sekaran, 2003). Reliability analysis revealed the Cα values for the model factors for Phase A were as shown in Table 7: related questions have reliability ranged between 0.72 and 0.80. Furthermore, reliability analysis revealed that Cα values for the model factors for Phase B were more than 0.80, as illustrated in Table 8.

Table 7 M-learning tool (Phase A)

Item	*Mean*	*SD*	*Cα*
Perceived usefulness (PU)			
PU1: Using m-learning system would be useful for my learning	3.78	.64	
PU2: Using m-learning system would enable me to achieve learning tasks more quickly	3.75	.68	
PU3: Using m-learning system would improve my learning output	3.82	.71	0.75
PU4: Using m-learning system could enhance my collaboration with colleagues	3.88	.68	
PU5: Using m-learning system would improve my efficiency in my studies	3.75	.77	

Table 7 M-learning tool (Phase A) (continued)

Item	*Mean*	*SD*	*Cα*
Perceived ease of use (PEoU)			
PEoU1: The m-learning system was useful to guide us step by step	3.61	.49	0.76
PEoU2: With m-learning system, it was easy to share location and files to my friends	3.51	.50	
PEoU3: I believe that m-learning system flexible and easy to use	3.92	.71	
PEoU4: Accessing course material with m-learning system would be clear and understandable	3.59	.54	
PEoU5: I believe that m-learning would be easy to operate	3.57	.50	
PE0U6: I would be comfortable to use the m-learning system in my study	3.61	.57	
Perceived learning (PL)			
PL1: The m-learning system helped me develop new skills that apply to my academic studies and/or professional life	3.47	.50	0.78
PL2: The m-learning system helped me connect ideas in new ways	3.43	.50	
PL3: The m-learning system helped me develop confidence in my learning	3.27	.49	
PL4: The m-learning system makes learning more interesting	3.53	.58	
PL5: The feedback property helped to improve my understanding	3.45	.54	
Perceived engagement (PE)			
PE1: The m-learning system motivated me to learn course material more than class activities	3.51	.70	0.76
PE2: My attention to the tasks was greater using the m-learning system	3.47	.83	
PE3: The m-learning system makes working in a group more easier	3.25	.86	
PE4: The m-learning system was more convenient compared to e-learning and traditional class	3.49	.78	
PE5: The m-learning system provides me with a collaborative learning environment	3.39	.60	
Behavioural intention to use (BI)			
BI1: I am willing to use m-learning system in my studies	3.73	.49	0.75
BI2: I will frequently use m-learning system	3.78	.46	
BI3: I will continue using of m-learning system in the future	3.80	.57	
BI4: I will recommend others to use m-learning system.	3.69	.58	

Table 8 M-learning tool (Phase B)

Item	*Mean*	*SD*	*Cα*
Perceived usefulness (PU)			
PU1: Using m-learning system would be useful for my learning	4.12	.68	0.86
PU2: Using m-learning system would enable me to achieve learning tasks more quickly	3.92	.74	
PU3: Using m-learning system would improve my learning output	4.10	.70	
PU4: Using m-learning system could enhance my collaboration with colleagues	4.14	.69	
PU5: Using m-learning system would improve my efficiency in my studies	3.10	.70	
Perceived ease of use (PEoU)			
PEoU1: The m-learning system was useful to guide us step by step	3.94	.51	0.91
PEoU2: With m-learning system, it was easy to share location and files to my friends	4.04	.82	
PEoU3: I believe that m-learning system flexible and easy to use	4.10	.57	
PEoU4: Accessing course material with m-learning system would be clear and understandable	4.06	.61	
PEoU5: I believe that m-learning would be easy to operate	4.12	.65	
PE0U6: I would be comfortable to use the m-learning system in my study	4.16	.83	
Perceived learning (PL)			
PL1: The m-learning system helped me develop new skills that apply to my academic studies and/or professional life	4.02	.58	0.87
PL2: The m-learning system helped me connect ideas in new ways	4.14	.66	
PL3: The m-learning system helped me develop confidence in my learning	4.02	.68	
PL4: The m-learning system makes learning more interesting	4.04	.63	
PL5: The feedback property helped to improve my understanding	3.96	.53	

Table 8 M-learning tool (Phase B) (continued)

Item	*Mean*	*SD*	*Cα*
Perceived engagement (PE)			
PE1: The m-learning system motivated me to learn course material more than class activities	4.02	.51	0.83
PE2: My attention to the tasks was greater using the m-learning system	4.02	.68	
PE3: The m-learning system makes working in a group more easier	3.94	.81	
PE4: The m-learning system was more convenient compared to e-learning and traditional class	4.00	.66	
PE5: The m-learning system provides me with a collaborative learning environment	3.84	.67	
Behavioural intention to use (BI)			
BI1: I am willing to use m-learning system in my studies	4.20	.72	0.88
BI2: I will frequently use m-learning system	4.21	.67	
BI3: I will continue using of m-learning system in the future	4.35	.72	
BI4: I will recommend others to use m-learning system.	4.22	.76	

The results showed that participants have a positive estimation of overall variables used in the questionnaire. Based on the results achieved, the construct 'mean for the students' questions varied between 3.43 and 3.80 (out of 5) for Phase A of the developed m-learning tool and the mean for all questions was 3.60, which is over 3. For Phase B of the tool the construct means varied between 3.97 to 4.22, with a total mean of 4.07. Table 9 compares the means of all constructs in Phases A and B.

Table 9 Mean differences between variables

Construct	*Phase A*	*Phase B*
	Construct mean	
PEoU	3.63	4.07
PU	3.80	4.08
PL	3.43	4.04
PE	3.42	3.97
BI	3.75	4.22
Total mean	3.60	4.07

The results in Table 9 indicated that the students found the m-learning tool easy to use, and they thought it would enhance their learning and improve their achievements These results are like that found by (Hsu et al., 2013; Hsu et al, 2016). Since the m-learning tool provides students with learning services like file view, text view, text feedback and blogging, these services and learning resources create collaborative learning between students together and would be helpful for most students to access and review their learning content (Troussas et al., 2014; DeWitt et al., 2014). In addition, the results revealed that the students highly engaged with the activities utilised in proposed m-learning tool; because of the design parts of m-learning tool that integrate mobile social settings, students can view files, upload/download videos, text their location and interact with the animation service. These results make learning more interested and help students developing innovative ideas in learning, the results agreed with (Rossing et al., 2012; Hsu et al., 2013; Hsu et al., 2016).

However, results show that students believe that using Phase B will be more useful, easier to use, achieve more learning engagement and behavioural intention to use. This reflects that Phase B has more advanced learning content characteristics and provides students with highly amenable learning resources in terms of learning style, learning collaboration, content format and content interactivity. Phase B supports rich content format and greater interaction. These factors would attract students' attention to use m-learning activities in their university context and would increase their engagement with these activities.

When students were asked which learning phase they preferred to have in their phones, the results indicate that most of them would prefer to have both stations installed at the same time, as illustrated in Table 10.

Table 10 Integrated services acceptance from both Phases (A and B)

Phase	*Frequency*	*Percent (%)*
Phase A	6	11.8
Phase B	10	19.6
Both together	35	68.6
Total	51	100

Additionally, some students preferred passive learning, standard content and low-level interaction, thus there is still a need for both phases to be available and utilised in learning.

5 Conclusion and future work

This work presented a new m-learning system prototype featuring several levels of user interaction and its ability to provide context-aware and ubiquitous learning services.

The development of the new m-learning prototype was based on a detailed description of m-leaning context factors defined through the extensive literature reviewed. Context factors were validated using quantitative study. The results indicated the salient importance of learning users' requirements and learning resources characteristics. Within user requirements, variables such as learning collaboration type, learning style and learning difficulties were measured. With reference to resources characteristics, content format and interactivity level were concerned. In summary, context analysis and validation results (Tables 2 to 6) indicate that the majority of users tend to be active and collaborative learners, utilising rich learning content with a high level of interaction with group or single peer learners.

An m-learning tool was developed implementing the proposed prototype. This tool consists of two functional phases operating based on predefined context factors, each of which provides a different level of learning services ranging from passive, offline and standard learning to real-time, rich and collaborative learning services. To evaluate this tool a quantitative study was applied to measure students' perception and satisfaction of using both Phases (A and B) using a set of quantifiable and technology acceptance variables, including *perceived usefulness*(PU), *perceived ease of use* (PEoU), *perceived learning* (PL), *perceived engagement* (PE), and *behavioural intention to use* (BI).

The results show that students believe that Phase B is more useful, easier to use, and achieves more learning engagement and *behavioural intention to use* than Phase A. This was due to the learning resources and interactivity levels supported by Phase B. Students benefit from active learning style and highly engaging m-learning services. However, the results also indicated that users prefer the availability of both functions Phases (A and B) in order to accommodate the broadest range of user requirements and to suit the technical capabilities of their mobile devices and internet service availabilities.

The evaluation results have confirmed the successful design and implementation of the proposed prototype by achieving a unified system which is adaptive to m-learning context environment and fulfils all user requirements. In future, the proposed m-learning tool will be developed and there is a need to evaluate the learning outcomes, students' engagement and their attitude considering specific classroom settings and precise learning scenarios.

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