Designing A Mobile Learning Application Based On The MOBIlearn Task Model

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Declaration

I hereby declare that the work described in this thesis is my own work, done by me and has not been submitted for any other degree anywhere.

Abstract

In the past few years, there are an increasing number of higher educational institutions offer courses using mobile technologies as a supplementary to traditional learning. However, there is a challenge to set guidelines for appropriate use and to provide tools and resources for personal learning activities across contexts. The purposes of this research study therefore are to provide guidelines for appropriate use of a mobile learning application and design it as tools based on MOBIlearn task model to support personal learning activities in formal, informal and non-formal educational contexts. The study begins by conducting a systematic review to synthesize pedagogical requirements from the task model. In the next part, the study adopts multiple-case study as a methodology to evaluate learners' experiences of using the application designed based on the requirements. At the end, a cross-case analysis is conducted in effort to find emerged patterns of data from all the case studies. This study successfully produces guidelines for appropriate use of mobile learning application based on learning contexts and finds that different priority needs to be considered for each context in order to provide it as personal learning tools for mobile learners. In addition, the study generates a series of implementation steps to employ a mobile learning application into a blended or hybrid learning and finds that the task model should be enhanced to provide better understanding and to keep it relevant for future reference. Importantly, this study contributes a new deep understanding and insight on the task model and provides guidelines for appropriate use and designing a pedagogically sound mobile learning application to support learning activities. Furthermore, the study significantly expands research into how mobile learning applications are actually used by students to support their personal learning in educational contexts.

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Journal publication

1. **Jalil, A.**, Beer, M. D., and Crowther, P. (2015). Pedagogical requirements for mobile learning: A review on MOBIlearn task model, *Journal of Interactive Media in Education*, vol. 2015(1), no. 12, pp. 1–17, Aug. 2015.

Conference proceeding

1. **Jalil, A.**, Beer, M. D., and Crowther, P. (2016, December 2-4). *Improving design and functionalities of MOBIlearn2 application: A case study of mobile learning in Metalwork Collection of Millennium Gallery*. Proceedings of IEEE 8th International Conference on Technology for Education, Mumbai, India, pp. 19-25. Indian Institute of Technology Bombay, India: IEEE Computer Society.

IEEE Bulletin

1. **Jalil, A.**, Beer, M. D., and Crowther, P. (2015). *Mobile learning in a seminar or workshop: A case study for evaluating MOBIlearn2 basic components and their application.* Bulletin of the IEEE Technical Committee on Learning Technology, vol. (17), no. 4, pp. 30-33, Dec. 2015.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Whilst there have been many experiments in mobile learning, they have all been based on custom apps that have been specially written for a task. This is time consuming and expensive as well as difficult to keep up to date. This research study has a methodology and a framework which provides the basis for a common app which can be used by teachers in the same way as they use learning management systems such as Blackboard to rapidly and comparatively cheaply develop their own mobile learning material which they can maintain an update regularly, as required. This thesis presents the design of a mobile learning application based on MOBIlearn task model in order to provide guidelines for appropriate use and tools for personal learning in mobile environment.

In this research project, pedagogical requirements are synthesised by conducting a systematic review on current literature of the contributing factors in the MOBIlearn task model. It proceeds with a design of mobile learning application prototype called MOBIlearn2 by mapping the requirements with components and functions that are built on Android-based platform and evaluate it in three separated case studies that represent three different mobile learning contexts (formal, informal and non-formal). Based on the results and feedback from participants in each case study, the prototype is refined iteratively to address their issues and improve its functionalities for a better design to support mobile learners in their learning activities. At the end of the study, a cross-case analysis was conducted and the findings were discussed in order to provide guidelines for appropriate use and tools for personal learning as

well as to confirm the task model as a reference to design a pedagogically sound mobile learning application.

In this introductory chapter, the thesis presents the background of the study; describes the statement of the research problem; states the research questions; describes the aim and objectives of the study; explains the significance of the study; and presents a guide to the thesis readers.

1.2 Background of the Study

The past decade has seen increasingly rapid advances in the field of mobile technologies and these have been used to support learning. Although research in this area began in the early years of 21st century, it is only recently that both technology and educational needs have converged as mobile communication and equipment technologies become capable enough to support mobile learning. The technology includes smart phones, personal digital assistants (PDA) and tablets whilst the new paradigm in education is on supporting the learner, in collaboration with peers and teachers, through a lifelong education, both within inside and outside the classroom (Taylor et al., 2006). These changes, together with the increase in power and usability of mobile devices and the speed of communication, result in a type of learning, which is called mobile learning that takes advantages of mobile technologies and communications to gain information and knowledge at anytime, anywhere and any pace.

Mobile learning can benefit educational institutions in terms of pedagogical practices to address student requirements for flexibility and ubiquity, which consequently will enhance their learning capabilities to achieve better performance (Hashim, Ahmad & Ahmad, 2011).

It allows educators to develop new ways of learning that are more tuned to the learner's needs. As an example, Zurita and Nussbaum (2004) have demonstrated the effectiveness of wireless mobile devices in learning to construct words from syllables. In their experiment, the children who were supported with technology had obviously higher test score improvements than the children who were using paper-based activities. Churchill (2011) has stated that mobile learning provides a learner with access to information and multimedia resources within the context of learning activities. The author has reported a variety of situations for mobile learning: during classes to enable teachers and students to share files, ask anonymous questions, answer polls and give feedbacks; courseware and quizzes delivery; intelligent tutoring system; for dissemination of information and collection of data during field work; support students' inquiries; collaborative and lifelong learning; and for disadvantaged young adults to enhance literacy and numeracy skills. Peters (2007) has concluded in her study that mobile learning is clearly able to provide learning that is 'just in time', situated and contextualized as well as capability for learning that can be tailored to the needs of the individual learner from diverse backgrounds.

One of the projects that has shaped research and development of mobile learning in Europe is MOBIlearn. The project aimed to develop, implement and evaluate architecture for mobile learning based on theories of effective teaching and learning in a mobile environment (Kukulska-Hulme et. al., 2009). A great outcome from this project is a task model analysis framework for mobile learners (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006). The objective of the framework is to capture the complexity of mobile learning system or environment that consists of semiotic and technological spaces. It has six contributing factors, which are tool, subject, object, control, context and communication that affect the effectiveness of mobile learning implementation. **Figure 1.1** presents the MOBIlearn task model framework with its contributing factors.

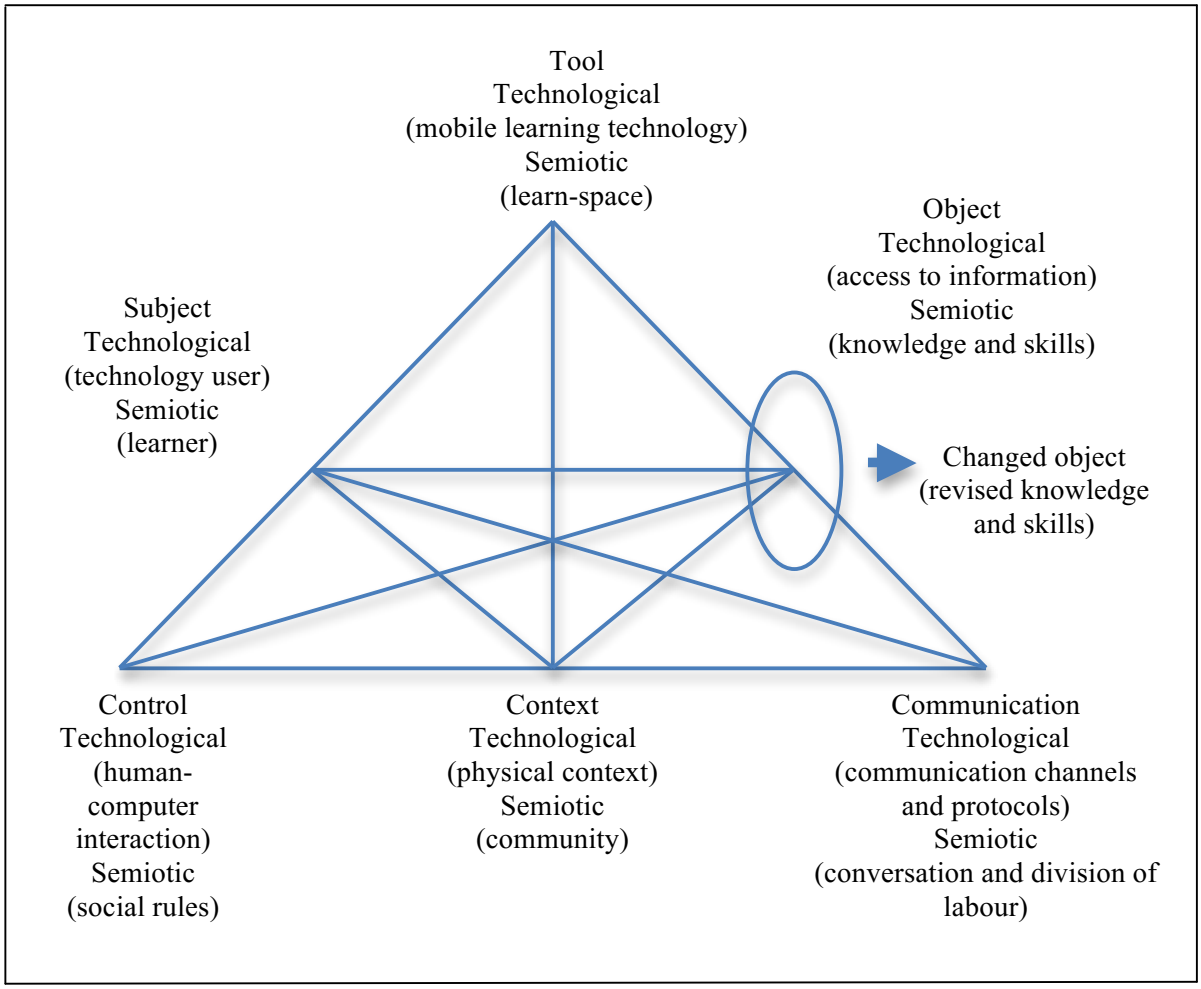


Figure 1.1: MOBIlearn task model framework (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006).

The MOBIlearn task model framework 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 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 1.2** shows how the task model provides a bridge to a cycle of iterative design.

As shown in the figure, the development process of the MOBIlearn task model was started with 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.

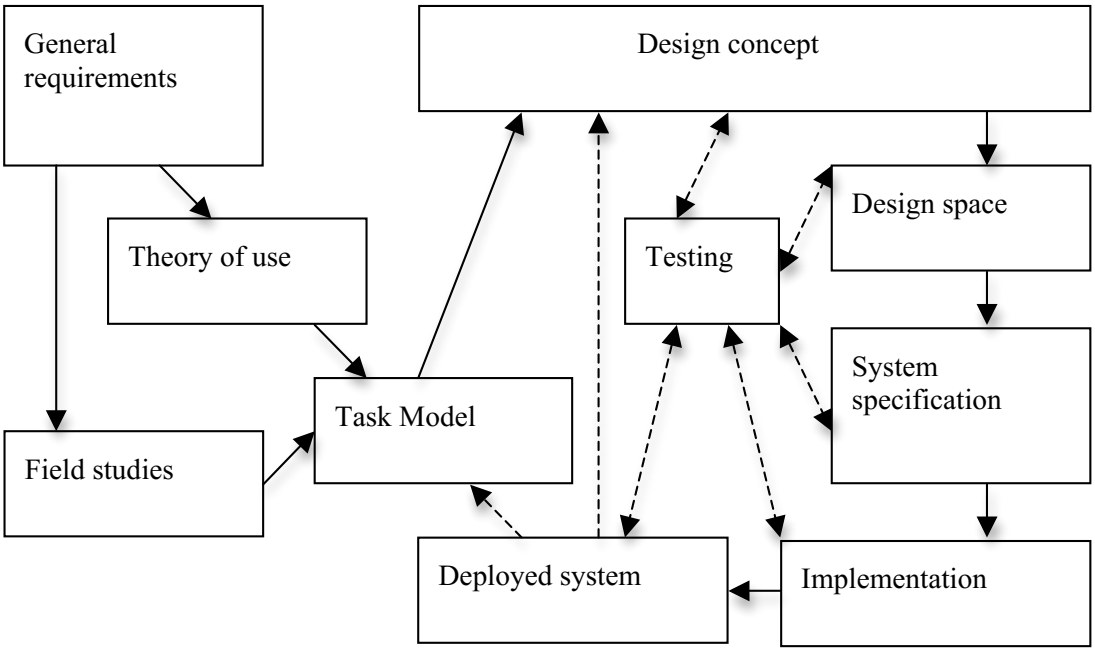


Figure 1.2: Flow and main product of design process (Bo, 2005; Taylor, et al., 2006).

The MOBIlearn task model served 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). The use of the task model enabled the capturing of many possible interactions learners may engage in as they move around their

respective environments (Bo, 2005). The author 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.

Given the reasons, the MOBIlearn task model is examined in this research project. By applying the task model to produce a practical mobile learning application, the study provides more understanding and clear guidelines for learning application designers and higher institutions to leverage mobile technology for the benefit of mobile learners.

1.3 Statement of the Research Problem

According to Pollara and Kee Broussard (2011), students have positive perceptions on mobile learning as they see this type of learning can provide enjoyable and convenient environments as well as strongly generate their interest in learning. As demonstrated by a study, they are more comfortable using mobile phones for learning, and almost half (45%) of the research group are prepared to use Internet-enabled phones as their learning tool (Fannon, 2005). Furthermore, higher institutions are increasingly recognizing student preferences, technology affordability as well as pedagogical practices to gain the benefits of an effective mobile learning environment. For example, a study in University of Texas at Brownsville has found that 94% of its students and 60% of its staff are ready to adopt and implement mobile learning for their courses (Corbeil and Valdes-Corbeil, 2007). Therefore, it is ideal to develop innovative strategies to integrate mobile application in learning and teaching (Botzer & Yerushalmy, 2007).

However, there is a challenge to set guidelines for appropriate use and to provide tools and resources for personal learning that integrate with commercial applications (Sharples, 2013). There is still little understanding of the ways mobile application can be developed to support contextual, interactive and social learning in mobile environment (Uden, 2007). The development tools and standards for an e-learning environment are not completely appropriate to create an application for mobile learning platform as it differs in concept and practice (Bo, 2005). In addition, Peters (2007) has reported that although mobile technologies and applications are in common use in some commercial sectors, their use purely for learning is rare. Despite the fact that many mobile applications are being developed for all walks of life, educational applications do not seem to receive attention from designers and developers in the beginning stage of mobile development (Paliwal & Sharma, 2009). According to Bruck, Motiwalla and Foerster (2012), mobile learning applications are not very popular and are not priorities for developers in spite of the explosive growing number of mobile devices.

In response to the problem, this research project attempts to design a pedagogically sound mobile learning application based on the MOBIlearn task model in order to provide guidelines for appropriate use and tools for personal mobile learning activities across different contexts. As a first step, a systematic review on the contributing factors in the task model is conducted in order to synthesize a set of pedagogical requirements for mobile learning. However, the review ignores the tool factor, as sound pedagogy is not tied with any device or space (Sharples, Taylor & Vavoula, 2005; Taylor et al., 2006). Then, an initial design of Android-based MOBIlearn2 application prototype is developed according to the requirements and evaluated in three separated case studies that represent formal, informal and non-formal mobile learning contexts. The results and feedback from each case study are analysed to iteratively improve the design and functionalities of the prototype. At the end, a

cross-case analysis is discussed to present new insights and emerged patterns of data that are expected to gain in the research project.

1.4 Research Questions

The problem statement mentioned in the previous section and the task model analysis framework produced by the MOBIlearn project serve as a basis to define key research question. The key research question is:

RQ. How to design a mobile learning application based on MOBIlearn task model in order to provide guidelines for appropriate use and to provide tools for personal learning?

To answer the key question above and be more specific, this research project divides it into four sub questions as follow:

1. What are the learning activities performed and resources accessed by learners in mobile environment?

This question attempts to understand what are learning activities performed by mobile learners and what are learning resources accessed by them by systematically reviewing the factors of subject and object in the MOBIlearn task model.

2. How control, context and communication could support pedagogical needs in mobile environment?

This question attempts to understand how the factors of control, context and communication in the MOBIlearn task model could support pedagogical requirements for mobile learners.

3. How do learners experience the learning with the support of the mobile learning application designed based on the pedagogical requirements?

This question evaluates the learning experiences of the participants with the support of the MOBIlearn2 application designed based on the pedagogical requirements found in the MOBIlearn task model. It seeks to identify issues and obtain the perception and feedback from the participants regarding the use of the application in three different case studies that represent three learning contexts (formal, informal and non-formal).

4. How could a mobile learning application be designed for appropriate use and as tools for personal learning?

This question attempts to find emerged patterns of data from all of the case studies. The findings are analysed and discussed in effort to provide guidelines for appropriate use of mobile learning application and to provide it as tools for personal learning as well as to confirm the MOBIlearn task model as a design reference.

1.5 Aim and Objectives

This research study aims to design a pedagogically sound mobile learning application in order to provide guidelines for appropriate use and tools for personal learning activities by investigating the MOBIlearn task model. The specific objectives of the study are:

O1. To determine the pedagogical requirements for mobile learning from the MOBIlearn task model

O2. To evaluate learners experiences of using a mobile learning application designed based on the pedagogical requirements to support their learning activities

O3. To provide guidelines for appropriate use of mobile learning application and to provide it as tools for personal learning

O4. To confirm the MOBIlearn task model as a reference for the design of a pedagogically sound mobile learning application

To achieve the aim and objectives of the research, a three-part of study is conducted: first, to systematically review the MOBIlearn task model to synthesize pedagogical requirements to support mobile learners; second, to evaluate learners experiences of using a mobile learning application prototype which is developed based on the pedagogical requirements in three case studies to ascertain their needs and perceptions; third, to undertake a cross-case analysis in effort to find emerged patterns of data to provide guidelines and tools as well as to confirm the task model as a design reference.

In particular, the first objective is achieved through the findings of the systematic review in the first part of study whilst the second objective is achieved through the findings from all the case studies conducted in the second part of study. The third and last objectives are achieved through discussion from the cross-case analysis in the last part of this study.

1.6 Significance of the Study

This is the first research study that provides a combined understanding amongst the contributing factors in the MOBIlearn task model and their implications in informing the design of a pedagogically sound mobile learning application. Most of the current works as surveyed in the systematic review focus on the factors singly and are not based on the task model. This view is shared with Frohberg, Goth and Schwabe (2009) as they have stated that other prior researchers have relied on single factor to structure their overviews of the mobile learning field. Often, previous studies lacked a connection to theory and no theoretical framework is mentioned to support the research (Pollara & Kee Broussard, 2011). Those kinds of study do not provide as deeper and rich insights as this research study, which could contribute to the design improvement of mobile learning application and innovation. This research study therefore demonstrates the usefulness of the task model framework for the purpose of understanding the pedagogical requirements for mobile learning and as a design reference to develop a pedagogically sound mobile learning application.

To reiterate, the practical significance of the research results are the guidelines and design specification of a mobile learning application in enhancing educational practice through an innovation supported by hardware and software components that are available for mobile devices. To prove this innovation works, the research study seeks to get feedback and recommendations by student participants on the design and functionality of the application tested in multiple case studies. The findings from the evaluation of the application are discussed to provide guidelines for appropriate use and tools for personal learning as well as to confirm the task model as a reference for analysis and design stages of mobile learning application development. Therefore, this research study attempts to move a step further in the current mobile learning research by contributing a practical application of the MOBIlearn task model.

Other works in design practice of mobile learning application and innovation can refer to this case illustration. Hence, this research is foundational for improving learner experiences to learn in mobile learning environments in effort to support educational goals.

1.7 Structure of the Thesis

Structure of the thesis presents a map for the readers to navigate their way through the thesis as well as provides a pathway for the remaining chapters. As illustrated in **Figure 1.3**, the structure shows how the chapters and concepts are interconnected throughout the research project. The highlighted background indicates the current chapter where are the readers in.

Chapter 2 **Mobile Learning**

This chapter introduces the fundamental concepts of mobile learning including its definitions, types and theories of learning. Then, six popular models and frameworks of mobile learning including FRAME, Kearney's pedagogical framework, m-learning adoption model, classification matrix and Motiwalla's m-learning framework are reviewed to provide justification of the MOBIlearn task model as the research theoretical framework for further investigation in the research project. The summary is provided at the end of the chapter to conclude the review.

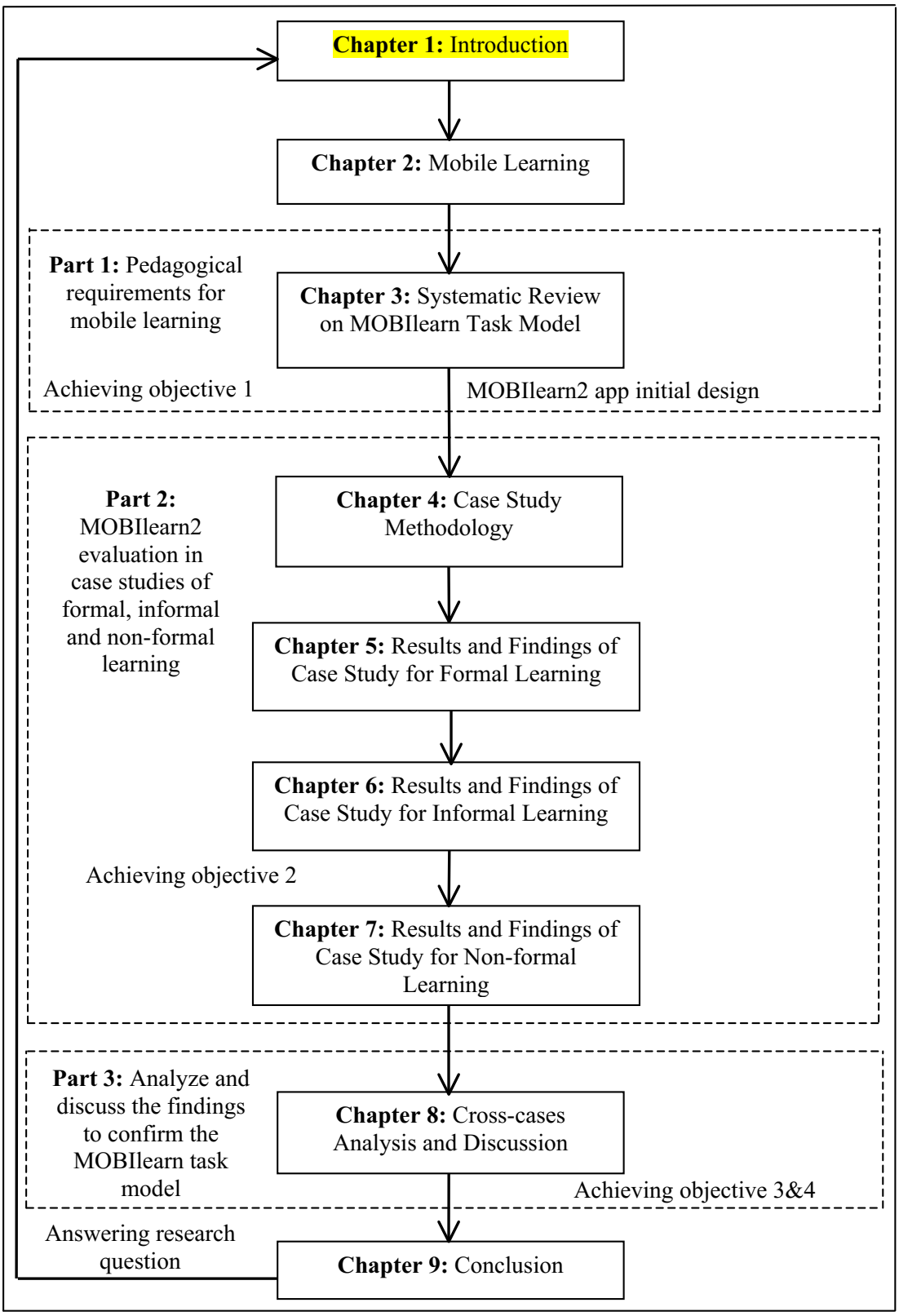


Figure 1.3: Structure of thesis for designing a mobile learning application based on MOBIlearn task model

Chapter 3 **Systematic Review on MOBIlearn Task Model**

The first section of the chapter introduces the current issue on mobile learning application, describes the significance of the systematic review and establishes the research questions to guide the review. The chapter then describes the MOBIlearn task model and proceeds with explanation of the methodology of the review study. Next, each factor in the model is examined to synthesize pedagogical requirements for mobile learning from the selected published research articles. Results conclude that mobile learners are continually collecting digital data or files on the move and collaboratively working together to achieve learning goals.

In addition, optimal level of control, contextualized environment and communication channel could support pedagogical needs for mobile learners. The results are discussed to propose an initial design of MOBIlearn2 application at the end of the chapter.

Chapter 4 **Case Study Methodology**

This chapter explains case study methodology and justifications of the methods used to evaluate learners experience of using MOBIlearn2 application prototype in the research project. In particular, this chapter describes in detail three different case studies that represent three different mobile learning contexts (formal, informal and non-formal) to collect data from the participants. The first case represents the mobile learning in a seminar or workshop, the second case represents the mobile learning in Metalwork Collection of Millennium Gallery and the last one represents the mobile learning to explore Sheffield Hallam University. Case selection, data collection methods and data analysis technique for each case study are also explained in detail in the chapter.

Chapter 5 **Results and Findings from Case Study of Formal Learning**

This chapter presents the results and findings from a case study for formal mobile learning in a seminar or workshop. The case study focuses on the evaluation of basic components that make up the MOBIlearn2 application for supporting students attending a one hour seminar or workshop of their choice. The data from a qualitative survey and semi-structured interviews are presented, analyzed and discussed in order to discover any issue on the components of the application and to get suggestions for future enhancement for the next case study. The findings show that the application is highly suitable for the students to collect data for their leaning activities and it is essential to include them in the design stage of the application development.

Chapter 6 **Results and Findings from Case Study of Informal Learning**

This chapter presents the results and findings from a case study of informal mobile learning in Metalwork Collection of Millennium Gallery in Sheffield. In particular, the chapter discusses about the evaluation of the MOBIlearn2 application in order to see how it could support mobile learners to learn in an informal learning setting such in a gallery visit. The data from semi-structured focus group interviews and direct observation are presented, analysed and discussed to evaluate the participant experiences. The results show that in spite of several technical errors and issues, which need to be addressed in the original prototype in order to improve its design and functionalities, participants found that the application is very useful to collect data and share visit experiences. At the end of the study, a new design with additional functionalities is proposed based on the feedback of the participants.

Chapter 7 **Results and Findings from Case Study of Non-formal Learning**

This chapter presents the results and findings from a case study of mobile learning by exploring several places in Sheffield Hallam University. The case study focuses on the evaluation of learners experiences in using the MOBIlearn2 application to complete a given tasks in a group by exploring several locations in the university. The data from semi-structured focus group interviews and direct observation are presented, analysed and discussed in order to discover any issue on the components of the application and to get comments and suggestions for its final design and future development. The results show that all of the participants found the application is very useful and could be used to collaborate on a task.

Chapter 8 **Cross-cases Analysis and Discussion**

This chapter presents an analysis and discussion by comparing and contrasting the findings from all case studies to identify similarities and differences in order to get new insight and pattern from the data. From this analysis, a set of recommendations and general features are generated in effort to provide guidelines for designers and educators to design a mobile learning application across contexts. A series of step to implement blended or hybrid learning with the support of a mobile learning application is mentioned as well. Finally, an enhancement of the MOBIlearn task model is proposed in order to provide better understanding and for the model to stay relevant.

Chapter 9 **Conclusion**

This chapter presents a conclusion derived from the findings of the research study. It recalls the big idea of the study, study settings, methods and experimental design to provide a background context and summarizing the findings in order to answer the research questions. Particularly, this chapter concludes the application and generalization of the findings in a bigger picture and presents the contributions of the research study to knowledge.

CHAPTER 2

MOBILE LEARNING

2.1 Introduction

In this chapter, this research project presents a review of fundamental concepts of mobile learning that begins with its definitions, types and learning theories behind it. It then proceeds with a brief overview of six most popular mobile learning models and frameworks that are found in literature and compare each of them to justify a model or framework of choice for further investigation in this research project as presented in the next chapter. A summary of understanding is presented at the end of the chapter to conclude what has been learned from this review and plan for the next step for this research project.

2.2 Definitions of mobile learning

In initial research works, mobile learning has been defined as part of electronic learning that uses mobile and wireless devices and technologies (Motiwalla, 2007; Anani, Zhang & Li, 2008). This definition refers to mobile learning as a subset, natural evolution and new stage of the electronic learning. It incorporates a number of activities conducted online and provides access to and dissemination of educational materials and knowledge for learners in remote location. However, Jeng et al. (2010) have argued that mobile learning is diverse from the conventional electronic learning, which happens on any pervasive computing devices. In a similar view, electronic learning is considered to be tethered and presented in a formal and structured manner, whilst mobile learning is untethered and informal in its

presentation (Mehdipour & Zerehkafi, 2013). Moreover, mobile learning has different characteristics and its own terminologies (Korucu & Alkan, 2011).

Another viable definition of mobile learning is about the advent of mobile technologies, which has created the opportunities for delivery of learning via mobile devices such as PDA, smart phone and tablets (Peters, 2007). The mobile technologies include SMS, MMS, WAP, GPRS, Bluetooth, Wi-Fi, 3G and 4G mobile phones, GPS and cloud storage. According to Mobile Learning Network project (MoLeNET, 2011), mobile learning is defined as "the exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning". Similarly, mobile learning is seen as the learning accomplished with the use of small and portable computing tools facilitated by convergence of the Internet and wireless technology to provide one-to-one interaction between learners and their mobile devices (Motiwalla, 2007; Liaw, Hatala & Huang, 2010).

From a bigger scale project and perspective, mobile learning definition has been refined to focus on the mobility of learners who move between different contexts in their daily life (Laouris & Eteokleous, 2005; Sharples, 2007; McAndrew, Taylor & Clow, 2007). In MOBIlearn project, it is described as any sort of learning when the learners are not in a fixed location (mobility) and take advantage of learning opportunities by using mobile technologies (O'Malley et al., 2003). Sanchez et al. (2009) have discussed the term mobility, which includes the mobility in physical space, technology, conceptual space, social space as well as the learning which is dispersed in time across either formal or informal contexts. The authors' point of view is based on the previous of works of Taylor et al. (2006) and Sharples, Taylor and Vavoula (2007) who have concluded that mobile learning is a conversation in context enabled by the interaction through and with the mobile technology. In addition, the term mobility has been used to define mobile learning in the higher education landscape (El-

Hussein & Cronje, 2010). The authors have demonstrated mobile learning as any type of learning that takes place in learning environments and spaces which consist of the mobility of technology, mobility of learners and mobility of learning. This definition is depicted in **Figure 2.1** below.

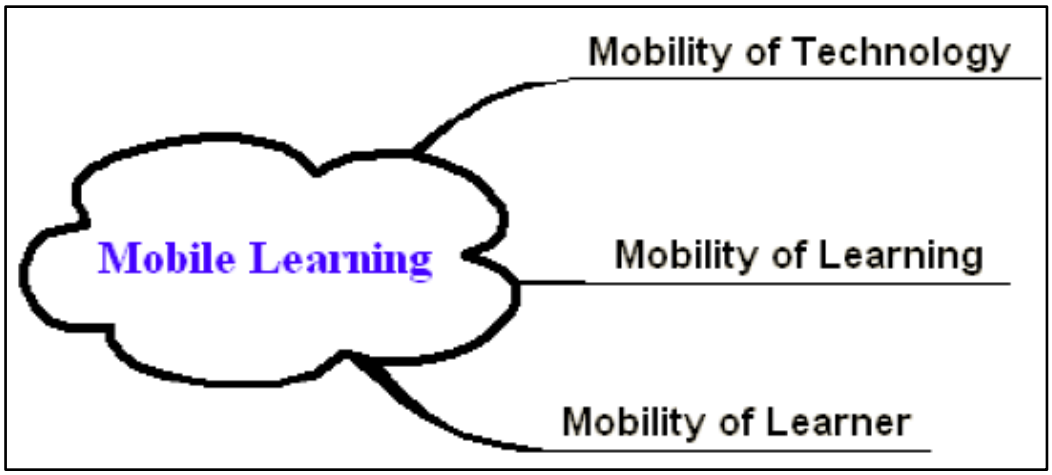


Figure 2.1: Divisions of mobility (El-Hussein & Cronje, 2010)

Patrichi (2010) has summarized that mobile learning consists of three elements including the process of learning itself, which is adapted to use the new technologies for delivering information or accessing knowledge. The second element, which is adaptation, is concern with the software and application whilst the technology as the final element is the hardware, devices or handheld equipment. In particular, Traxler (2005) has characterized mobile learning as spontaneous, private, portable, situated, informal, bite-sized, lightweight, context-aware as well as connected, personalized and interactive. Despite the increasing attention from conferences and publication, there is still no common understanding on the definition of mobile learning (Frohberg, Goth & Schwabe, 2009; Kukulska-Hulme et al., 2009).

2.3 Types of mobile learning

There are a few studies on effort to categorize formally the mobile learning due to its immature field and complexity of nature. Traxler (2007) has categorised mobile learning into six types which are technology-driven, portable e-learning, connected classroom, situated, training support and remote or rural mobile learning. In technology-driven mobile learning, there are specific innovations implemented in academic setting to demonstrate technological and pedagogical feasibility. Portable e-learning is adapting the same solutions found in e-learning to be used in handheld devices whilst collaborative learning is emphasised to connected classroom. Situated learning focuses on adding functionality to enhance student's experience in contrast with training support, which is to improve productivity of mobile workers. Lastly, the remote mobile learning is deployed to address infrastructural challenges to deliver education in rural area.

Recently, there are several categorization efforts that have been made usually to structure the understanding of mobile learning before going to more details on the objectives of particular research. For example, Frohberg, Goth & Schwabe (2009) have classified the types of mobile learning based on the factors of context, which are independent, formalized, physical and socialized. This context-based classification considers the environment of where the learning is taking place. Another example is what has been done by Wong (2012) to define the features of mobile seamless learning. The author has pointed out that mobile learning can be loosely divided either into informal or formal, personal or social and physical or digital. However, the author has not discussed them in detail except as continuum learning spaces in seamless learning.

More formal work has been presented by Park (2011). The author has proposed four types of mobile learning, which are type 1 (high transactional distance and socialized

activity), type 2 (high transactional distance and individualized activity), type 3 (low transactional distance and socialized activity) and type 4 (low transactional distance and individualized activity). This classification is generated based on the combination of Moore's transactional distance theory and activity theory represented by y-axis and x-axis respectively as shown in **Figure 2.2**.

The author has defined the types with certain attributes to indicate the level of transactional distance and activity. For example, a mobile learning is classified as type 1 if the learners have: (1) more psychological and communication space with teachers; (2) involved in group learning; (3) received predetermined learning content; and (4) interactions mainly occur among learners. Ultimately, the author has pointed out in his work that the most advanced form is type 3 in terms of versatility, but relatively few studies of this type exist.

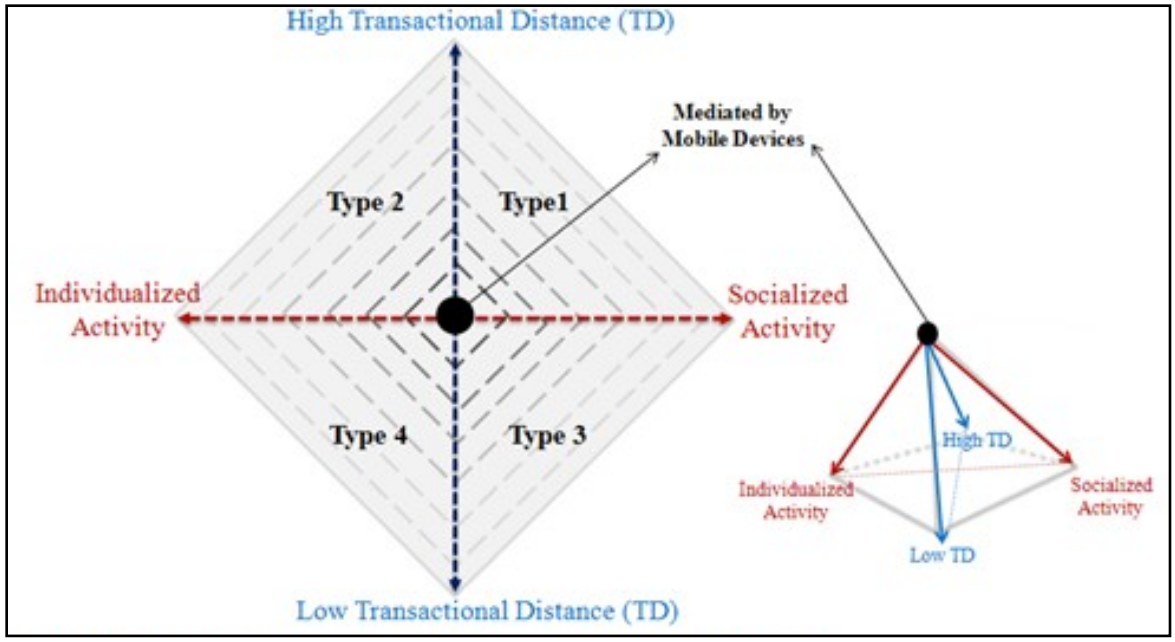


Figure 2.2: Four types of mobile learning (Park, 2011)

Sharples (2013) has identified some types of mobile learning across the dimension from curriculum-lead classroom such as handheld response systems to informal highly mobile such as social networking and collaboration with mobile phones. These types can be

demonstrated on a continuum from formal to informal settings as in **Figure 2.3**. In a similar view, Wu et al. (2012) categorize the mobile learning types into formal, informal and non-formal educational contexts. The authors point out that formal learning is highly institutional, bureaucratic and curriculum driven, whereas, informal learning is the unstructured learning that results from daily life activities related to work, family or leisure. Meanwhile, non-formal learning tends to be short-term, has few if any prerequisites and the student participations are more voluntary (Crowther, 2006). It can have learning objectives and strong emphasis on practical experience (Kyndt, Dochy & Nijs, 2009).

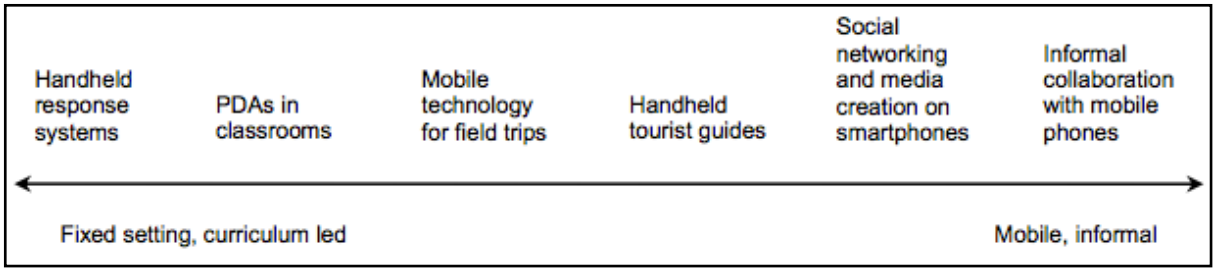


Figure 2.3: Types of mobile learning across the dimension from curriculum-led classroom to informal highly mobile (Sharples, 2013)

2.4 Mobile learning theories

There are several different established theories of mobile learning that become relevant for the current pedagogical practices (Naismith et al., 2008; Keskin & Metcalf, 2011). Some main theories that are frequently found in the literature are described in **Table 2.1** with their applications.

Table 2.1: Main theories underpinning the mobile learning pedagogy

Theories	**Description**	**Applications**	**References**
Activity theory	Learning that involves a subject (learners), an object (activity) and tool or mediating artefacts to support the learners in their goals of transforming their knowledge and skills. It uses the concept of activity as the fundamental unit of analysis to understand subjects' purposeful interaction with the world.	Gallery exhibition, mobile games	Vygotsky, 1986; Sharples, Taylor & Vavoula, 2007
Behaviourist learning	Learning as a change in observable actions. It occurs when there is an appropriate reinforcement of association between particular response and stimulus.	Text messages, classroom response system	Smith & Ragan, 2005.
Collaborative learning	Learning that is facilitated and supported by the interaction and communication between students. It combines the pedagogies of constructionism and social learning to provide richer interactions between learners and their concepts and practices. The learners are actively interact, share experience and engage in a common task.	Web 2.0, e-mail	Laurillard, 2009

Theories	Description	Applications	References
Constructive learning	Learners actively construct new ideas or concepts based on their previous and current knowledge. It means that they have to modify their current knowledge schemes to integrate new information and acquire new knowledge. They have to act and reflect in an environment as well.	Participatory simulation, handheld games	Vygotsky, 1978; Zurita & Nussbaum, 2004.
Conversational learning	Learning that is formed by the conversations between different systems of knowledge. It provides more optimal learning experience in both formal and informal contexts by sharing resources and outputs with other learners. To have a successful learning, it requires continuous two-way conversations and interactions between the teacher/learner and amongst the learners.	Field trip, laboratory classes	Sharples, 2002; Laurillard, 2007
Informal and lifelong learning	Learning beyond formal classroom and environment. It happens all the time autonomously, is influenced by environment and situations and supports both intentional and accidental learning episodes. It is unplanned, unstructured, and with unpredictable results.	Internet browsing, recording video, podcast	Sharples, 2000; Vavoula, 2004

Theories	Description	Applications	References
Situated or contextual learning	Learning within an authentic context or culture. It takes place in the surrounding applicable to learning. There are three subcategories under this type which are: (1) problem-based learning, that aims to develop critical thinking based on ill-defined problem; (2) case-based learning, that promotes discussion on real-world examples and: (3) context-aware learning, in which learning is informed by history and the environment.	Museum exploration, natural science learning	Sharples et al., 2007; Price & Rogers, 2004
Socio-cultural learning	Learning as an active process of building knowledge and skills through interaction with social environment and community. It focuses on the importance of social interaction and discussion as aspects of learning that makes use of communication technologies.	E-mail, social network	Vygotsky, 1978; Kim, 2000

Based on the theories that are explained in the table above, it appears that mobile learning pedagogy is a very solid learning pedagogy. The pedagogy provides collaborative approach whereby information and opinions are shared between the group members and experts via technology and tools. Moreover, it allows students to engage in high-order thinking tasks such as analysis, synthesis and evaluation in active environment. The

pedagogy also can be applied with blended approach in order to maximize the benefits of both face-to-face and online methods (Ozdamli, 2012). Recently, it is becoming more recognized and well accepted to be adopted into mainstream of education (El-Hussein & Cronje, 2010).

2.5 Models and frameworks of mobile learning

In this section, this research study briefly provides an overview of the main popular models and frameworks for mobile learning that are frequently found in literature. Only the models or frameworks that have a visual presentation either in a diagram or a table are selected for the study. Some significant strengths and weaknesses for each of them are highlighted for comparison purpose.

2.5.1 The FRAME model

The Framework for the Rational Analysis of Mobile Education (FRAME) model considers technical characteristics of mobile devices as well as aspect of social and personal learning (Koole, 2010). It is represented by a Venn diagram in which all of the three aspects intersect as shown in **Figure 2.4**. Device aspect refers to physical and functional characteristics of mobile device whilst learner aspect considers an individual's cognitive abilities, memory, knowledge, emotions and motivations. On the other hand, the social aspect takes into account the social constructivism, interaction and cooperation. The intersections where two circles overlap contain attributes that belong to both aspects (DL - device and learner, DS - device and social, LS - learner and social).

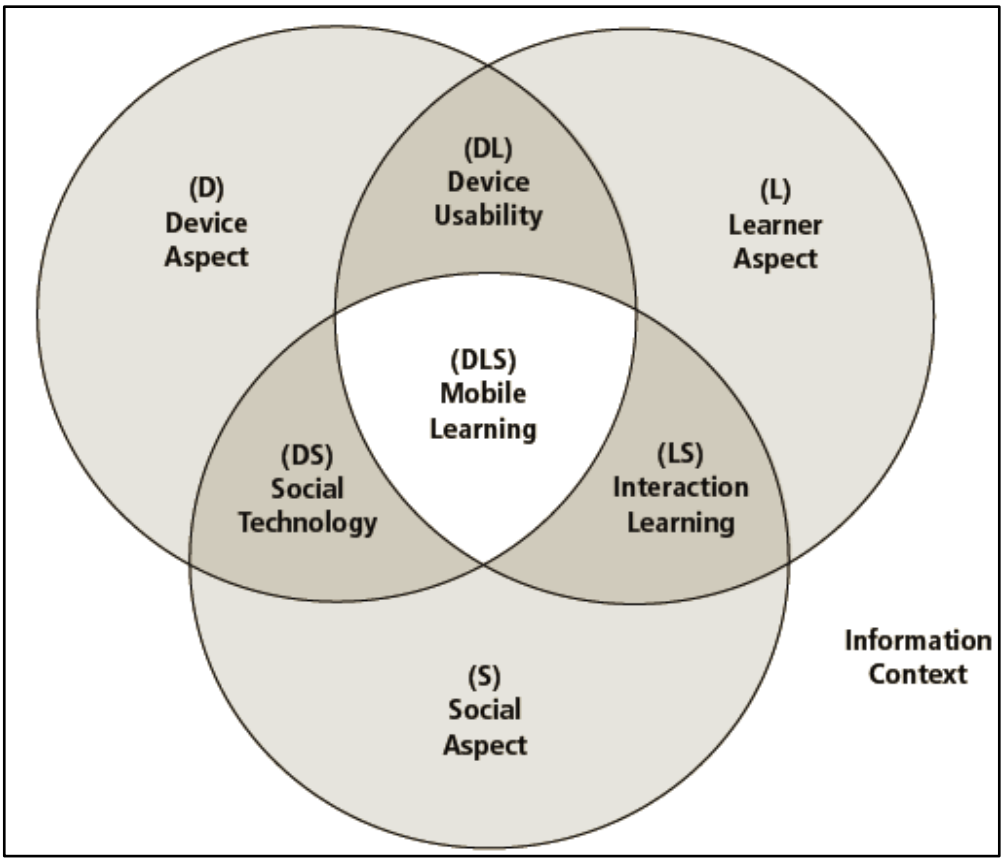


Figure 2.4: The FRAME model (Koole, 2010)

The centre of the diagram shows the convergence of all the aspects that define an ideal mobile learning environment. However, it is difficult to achieve an ideal mobile learning, as all the aspects need to work as a whole.

2.5.2 Mobile pedagogical framework

Kearney et al. (2012) has developed a mobile pedagogical framework through activities in two mobile learning projects located in teacher education communities. The framework is used to examine pedagogy in a set of reported learning scenarios in order to enable an evaluation of mobile activities and pedagogical approaches from the social-cultural lens. As shown in **Figure 2.5**, it highlights three main features,

which are: authenticity, collaboration and personalisation, encapsulated in the time-space contexts of mobile learning. The authenticity feature points out opportunities for contextualized and situated learning; the collaboration feature highlights conversational and communication aspects of mobile learning while the personalisation feature has strong influences on ownership, agency and autonomous learning (Kearney et al., 2012).

Despite it can assist the practitioner's understanding on pedagogical challenges and facilitate critical insights to mobile learning experiences, the authors have mentioned that there is a need to explore in more detail the time-space continuum as learning contexts occur in different places and at different times.

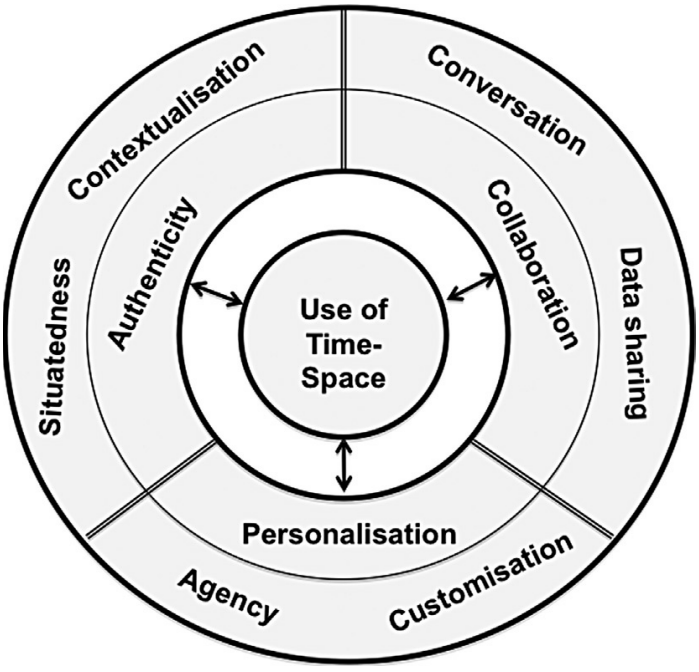


Figure 2.5: Mobile pedagogical framework (Kearney et al., 2012)

2.5.3 Model of m-learning adoption

Barker, Krull and Mallinson (2005) have proposed a model for m-learning adoption for developing countries as represented in **Figure 2.6**. The model combines the traditional learning environment that is supported by mobile learning policies and guidelines. Within an adopted mobile learning environment, the communication among the mobile devices is enabled by wireless access points. The communication includes learner-to-learner as well as learner-to-teacher interaction.

According to the model, the critical success factors are coordination, communication, motivation, mobility, interactivity, negotiation, collaboration and organisation of material. Coordination refers to interaction between learners while communication implies that a mobile learning environment needs to open communication channels between learners and teachers. Motivation refers to how the learning environment encourages learners to engage in learning and mobility is regarded as the portability of the devices. Interactivity represents the interaction between learners and their devices, negotiation allows consensus to be reached in learning activities, collaboration refers to partnership and organisation of material enables the proper information searching. As pointed out by Cobcroft (2006), these factors could support certain principles of effective university teaching.

However, the model is not suitable for other than developing countries and there are many critical factors that could hinder its success.

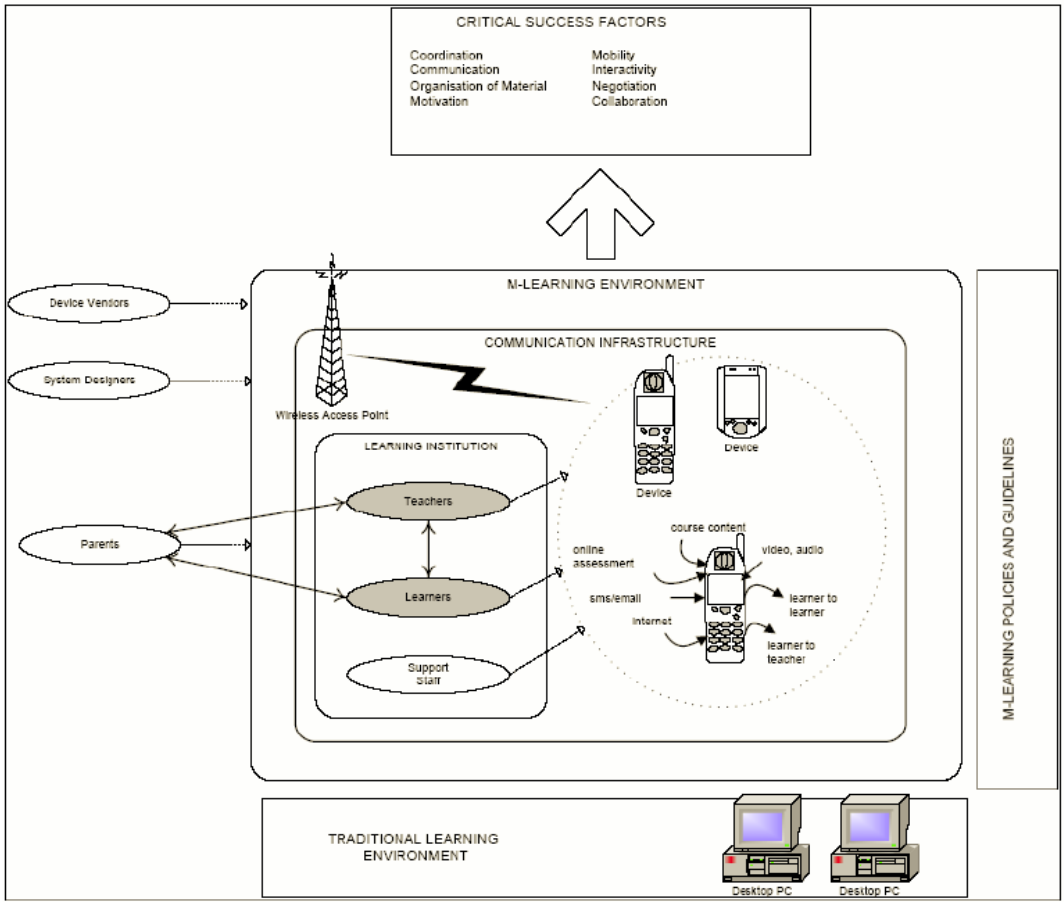


Figure 2.6: Model of m-learning adoption (Barker, Krull & Mallinson, 2005)

2.5.4 Classification matrix for a mobile learning model

To illustrate a model of mobile learning, Botha, Van Greunen and Herselman (2010) have explained on a classification matrix based on mobility and context of interactions as shown in **Figure 2.7**. Based on the matrix, mobile learning are characterised as low context and low mobility if the interactions are generally broadcasting information to a selection of users such as SMS to inform parents of school activities. On the other hand, the mobile learning interactions in the class of high context and high mobility actively use the context or environment that is on the move. The mobile learning examples under this category are GPS based games and

collecting data in a field study. For low context and high mobility, portable devices and users on the move are facilitated in the interaction, but with low physical context. Conversely, the user has a virtual context, but it is often structured and depends on physical environment.

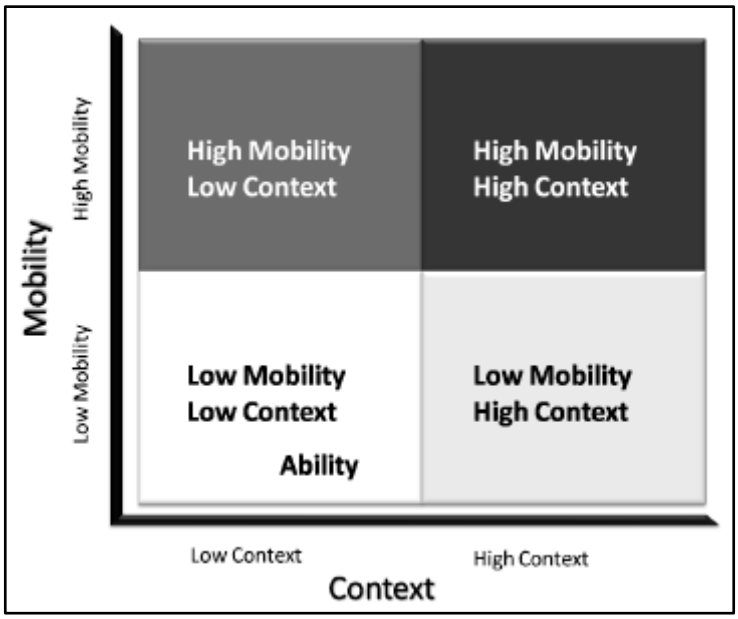


Figure 2.7: Mobility and context in MHCI (Botha, Van Greunen & Herselman, 2010)

Even though the model provides a clear classification of interaction, device and social limitations would restrict the type of interaction possible. For example, lower end mobile devices could not support the high context and high mobility interactions.

2.5.5 M-learning framework

A study by Motiwalla (2007) proposed an m-learning framework to provide requirements to develop m-learning applications that can be used to complement classroom or distance learning. It consists of two levels, which are *mobile connectivity*

that focuses on the applications and technology used by commercial establishments to extend e-commerce and *e-learning* that focuses on the use of Internet and other ICT in education. The framework is shown in **Figure 2.8**.

	Personalized Content	**Collaborative Content**	
PUSH Mechanism	*Pedagogical Agents & Mentors*	*Communication Aids*	*SMS, IM, Alerts, Scheduling Calendars*
PULL Mechanism	*System Tools & Resources*	*Simulated Classrooms*	*WML websites, Discussion Boards & Chat Forums*
	Alerts, Scheduling Calendars, WML websites	*SMS, IM, Discussion Boards & Chat Forums*	**M-learning Applications**

Figure 2.8: m-learning framework (Motiwalla, 2007)

Despite the framework is claimed to support constructive and conversational learning models, it seems that it is not suitable since it is developed based on an analysis of e-learning literature. This study argues that different approach must be taken to develop a framework for mobile learning as it has different characteristics compared to e-learning. As mentioned by Bo (2005), the standards for e-learning environments are not appropriate for other technology platform.

2.5.6 MOBIlearn task model

MOBIlearn is a European based research and development project that began from January 2002 to March 2005, which involved 24 partners from academia and industries in ten countries. The goal of the project was to develop, apply and assess architecture for mobile learning system, based on effective teaching and learning theories in mobile environment (Kukulska-Hulme et. al., 2009). One key

product of MOBIlearn is a task model for mobile learning developed based on Engestrom's activity system to show the process of interacting with objects using computer-based tools that enables transformations to occur in both the objects and also the individuals involved in carrying out work activities (McAndrew, Taylor & Clow, 2007). **Figure 2.9** shows the basic structure of the task model.

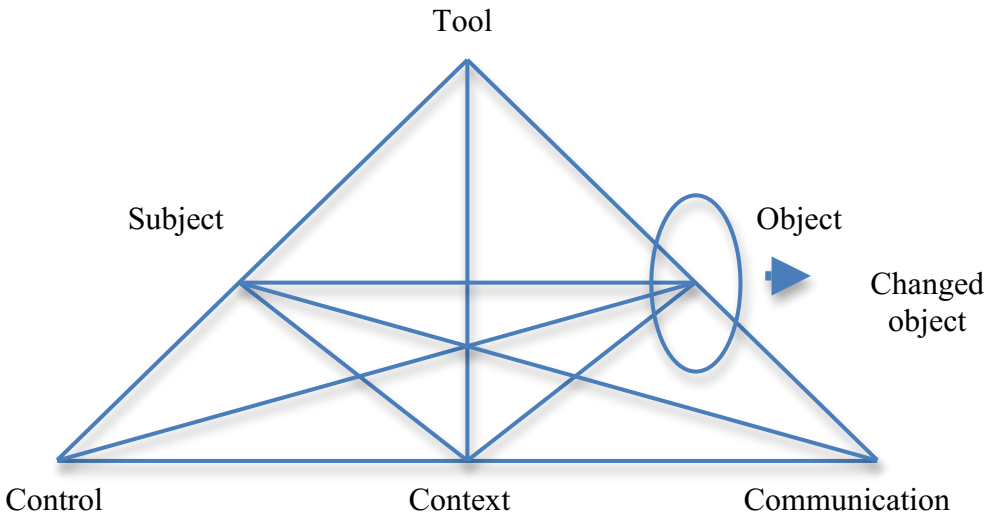


Figure 2.9: Basic structure of MOBIlearn task model

The aim of the task model is to understand mobile learning activity that incorporates the mediation of tools, occurs at the time preferred by learners, takes place in a contextualized setting and normally involves some sort of communication. The task model provides a lens to analyse learning processes and outcomes for the design of contextualized application of mobile learning (Uden, 2007). It clearly separates the required functionalities and their embodiment in any specific technology (McAndrew, Taylor & Clow, 2007). It is flexible when the learners are defined as 'mobile', not the mobile devices that they use and developed based on the theories of effective teaching and learning. Importantly, it is supported by Vygotsky's sociocultural, Engestrom's activity model, Laurillard's conversational theories of

learning (Sharples, Taylor and Vavoula, 2005; Taylor et al., 2006; Frohberg, Goth and Schwabe, 2009).

2.6 Summary

As found in literature, there are several different perspectives in defining mobile learning. Each definition emphasizes on different features such as the extension of e-learning, the advent of mobile technologies, and the learners mobility. Moreover, a few studies in the mobile learning field also have demonstrated some efforts to characterise the types of mobile learning in order to describe it in more detail and to provide a deeper understanding for current and future studies. As a result, it generally can be categorized into three different contexts, which are formal, informal and non-formal learning. Furthermore, the literature has pointed out that the mobile learning pedagogy is supported by a different type of learning theories such as behaviourism, constructivism, context awareness, collaborative, conversational, informal learning and activity theory. Hence, its pedagogy is well recognized and it is found that mobile learning is gradually embedded into mainstream education at all levels.

In the past few years, there are some popular models and frameworks developed specifically for mobile learning that have their own strength and weakness. However, it appears that the MOBIlearn task model is the best model that could be applied and implemented to inform the design of a mobile learning application to support learner activity in mobile environment. This research project needs to conduct a further investigation on the task model in effort to achieve its objectives. For the next chapter, the task model is explored and explained in detail with each of its contributing factors is systematically reviewed and analysed in order to extract a set of pedagogical requirements for mobile learning.

PART ONE

CHAPTER 3

SYSTEMATIC REVIEW ON MOBIlearn TASK MODEL

3.1 Introduction

In this chapter, a systematic review on the MOBIlearn task model to synthesize pedagogical requirements for mobile learning is presented. A systematic literature review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest (Kitchenham, 2004). The reason for this research project to undertake a systematic review is to summarize existing empirical evidences to provide in-depth understanding on the factors of the task model in effort to capture appropriate pedagogical requirements for mobile learning.

This chapter is a part of the thesis structure that present the first part of this research project. Most of the work in the chapter has been published in an open access journal (Jalil, Beer & Crowther, 2015). In particular, this review basically aims to develop an understanding of the MOBIlearn task model by providing the theories underpinning the development of the model and systematically reviewing its contributing factors on current literature. Then, this chapter presents the results and discusses the findings by listing out a set of synthesized pedagogical requirements for mobile learning. Finally, the requirements are mapped with a set of proposed components to provide functionalities in an initial design of a mobile learning application prototype called MOBIlearn2.

3.2 Background

Mobile learning is gradually gaining in popularity because of the increasing availability of low cost mobile and wireless devices as well as the supporting infrastructure and technology (Cobcroft et al., 2006). 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) pointed out that mobile learning provides a personalized platform of learning content where convenience in the access of resources is very critical. A 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 (Motiwalla, 2007).

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.

In addition, 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 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; Uden, 2007; Beckmann, 2010).

The significance of this systematic review therefore rests on the fact that there is limited work on how mobile learning application 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 review. 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 & Evans, 2005; Cobcroft, 2006). 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 research project 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, this chapter presents the task model framework generated from the MOBIlearn research project as background study. It then introduces a systematic review as methodology in order to conduct this research study comprehensively. Later, all the contributing factors of the model related to review questions laid out in this section are examined and the findings of this review are briefly discussed in the Results and Discussion section. Finally, this chapter concludes the review study and suggests future works in the following section.

3.3 MOBIlearn task model

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 3.1**, 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 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.

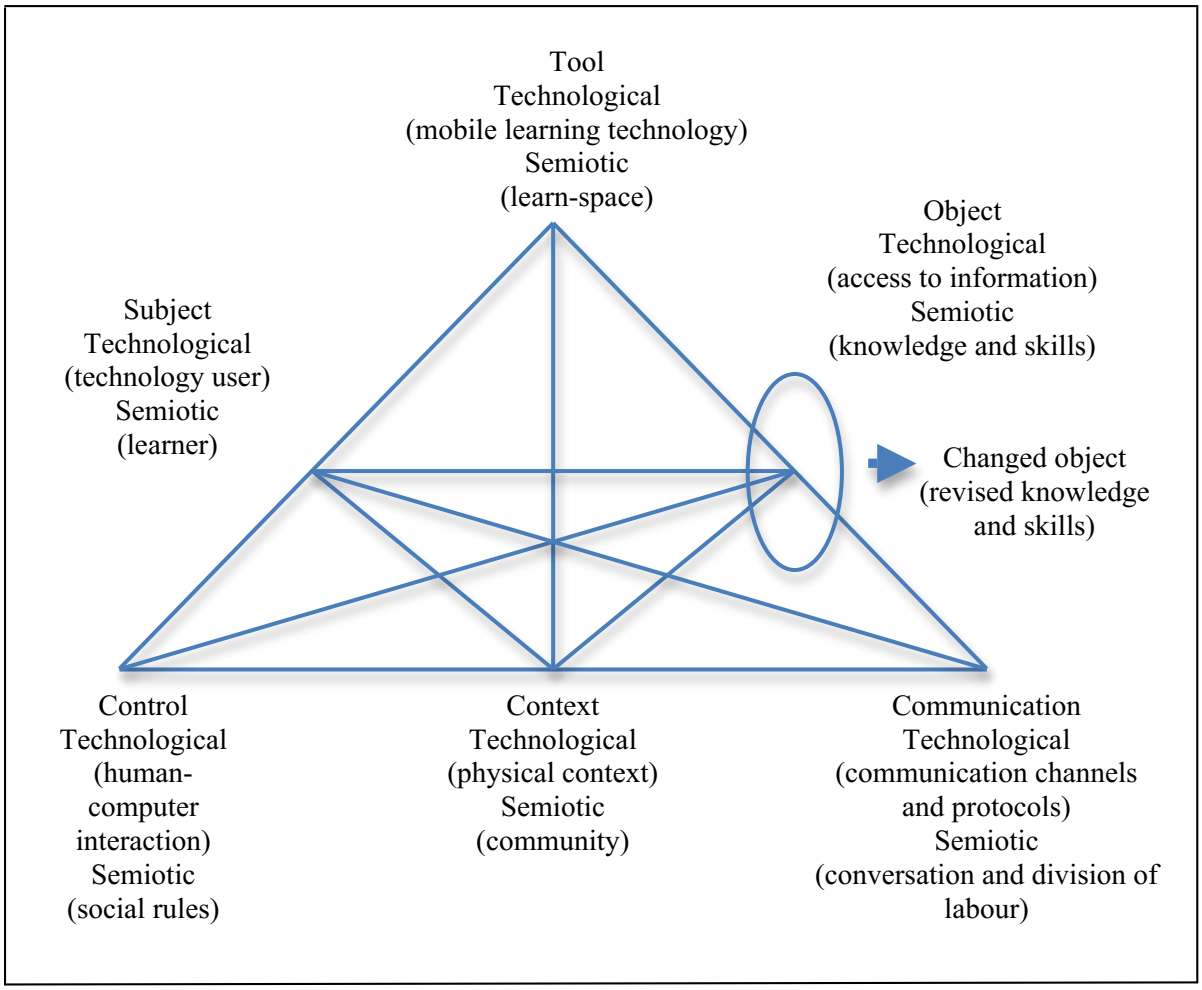


Figure 3.1: A task model for mobile learners (Sharples, Taylor and Vavoula, 2005; Bo, 2005; Taylor, et al., 2006).

Taylor, et al. (2006) has 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 3.2** and **Figure 3.3**.

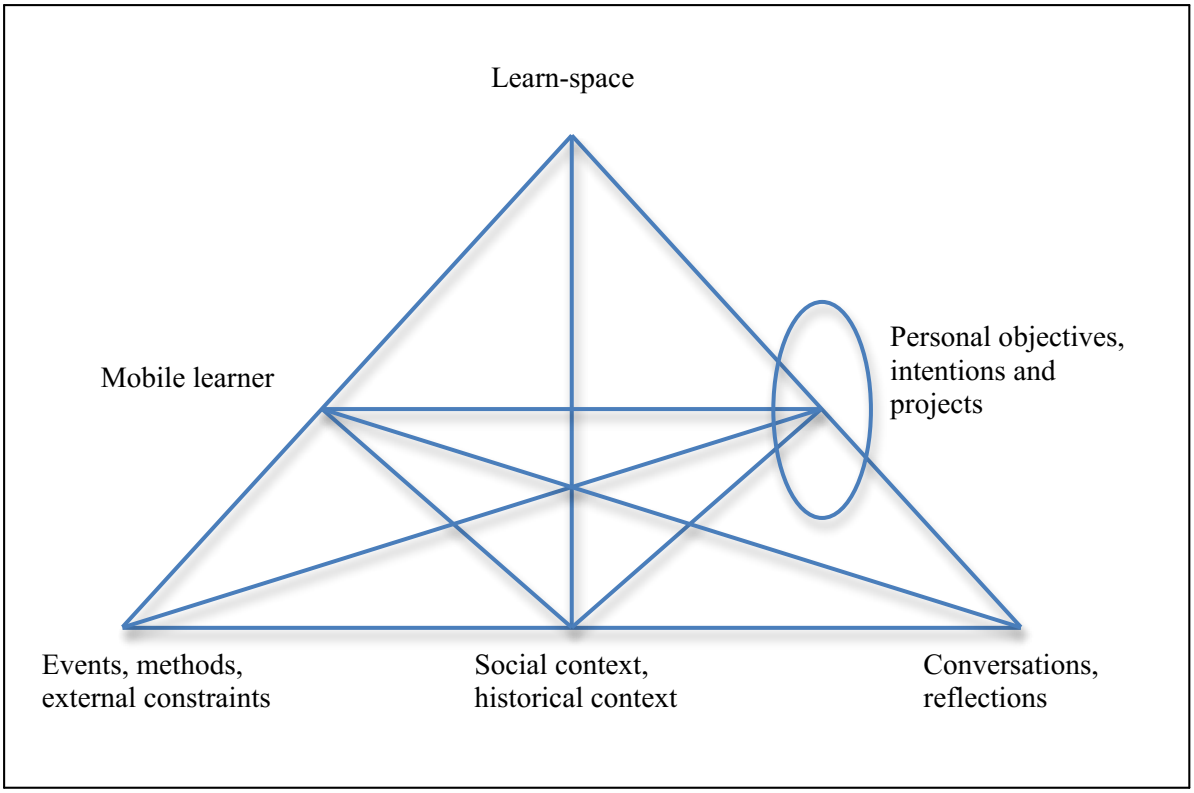


Figure 3.2: Mobile learning episodes in the semiotic space (Vavoula, 2005).

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.

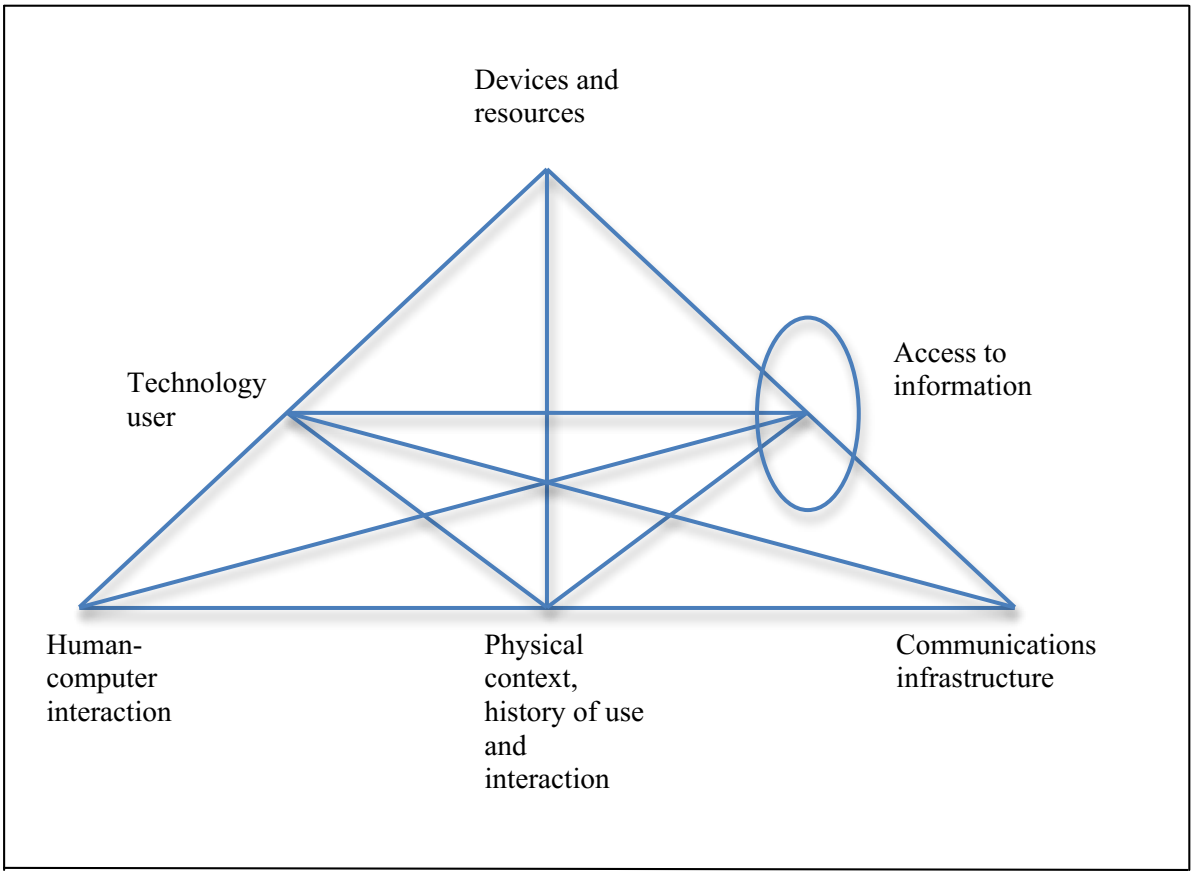


Figure 3.3: Mobile learning episodes in the technological space (Vavoula, 2005).

Sharples, Taylor and Vavoula (2005) have argued that the layers can be laid over (as in **Figure 3.1**) 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, this chapter briefly introduces systematic review as research methodology to answer the research questions stated previously.

3.4 Methodology

As mentioned before, this review 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, a systematic review is conducted 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). This methodology is chosen as it appears to be 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 the context of work, this review study uses five steps of systematic review, which has been introduced by Khan et al. (2003) for science-based researchers. The five steps 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.

3.4.1 Framing questions for a review

The research project has 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 is believed to be very critical for pedagogical purposes. Both framed questions will guide this review in the subsequent steps.

3.4.2 Identifying relevant work

This review is limited to the research questions that are previously established. It breakdowns the questions into individual factors (subject, object, control, context and communication) in order to come up with the terms to be used in search strategy. As mobile learning is a quite new area, the study reviews publications starting from 2001 until 2014 so that the state-of-the-art of current research could be understood. The 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 this review excludes all the works that do not discuss any of them. This review is also limited to the papers or articles that could be accessed directly through online database in the university's library website.

3.4.3 Assessing the study quality

While many of the previous studies focused on mobile learning theory, this review sought to explore the educational-oriented studies which are successfully published in certain peer-reviewed journals and conference proceedings. In order to avoid bias, this review

includes publications that report both positive and negative results. Moreover, the review focuses 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.

3.4.4 Summarizing the evidence

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

3.4.5 Interpreting the evidence

Once the most relevant key points related to the pedagogical requirements for mobile learning from the previous key studies have been identified, they are grouped into similar concepts which are corresponding to the task model contributing factors (Glazer and Strauss, 1967). By this technique, this review is 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 this research project to reason deeply in order to answer the 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 the review according to each factor of the model.

3.5 Contributing factors in the MOBIlearn task model

3.5.1 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 of web 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).

3.5.2 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 learn-

ers 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).

3.5.3 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).

3.5.4 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 3.4**.

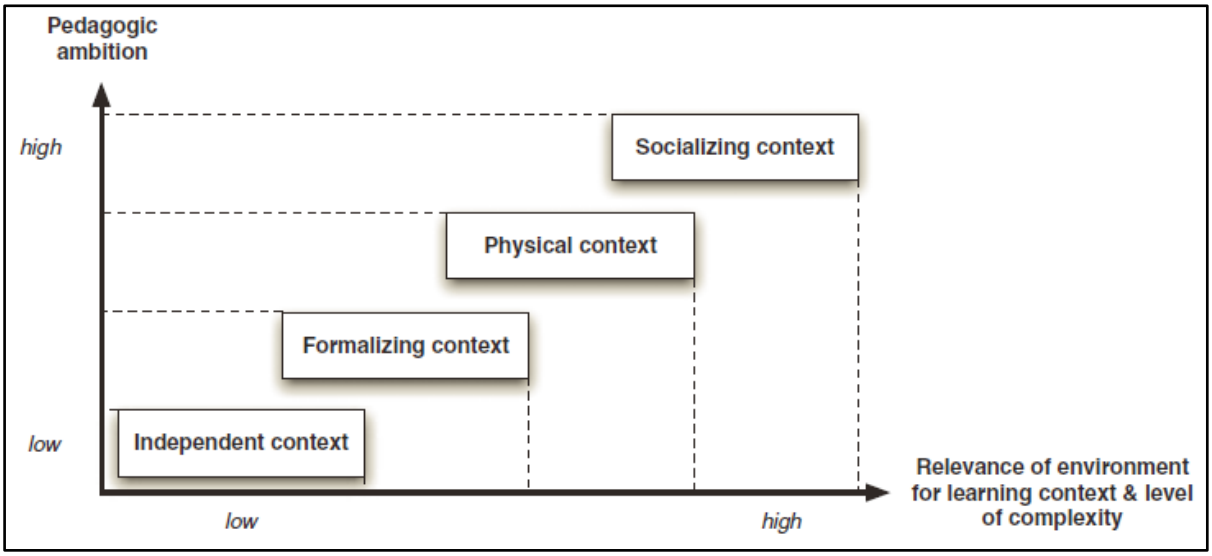


Figure 3.4: Classification of context (Frohberg, Goth and Schwabe, 2009).

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 user 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.

The seamless integration of the learning experiences across multiple contexts also plays an important role to provide effective learning for mobile learners. 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. The features include formal and informal learning, personalised and social learning, learning across time, learning across locations, ubiquitous access to learning resources, physical and digital worlds, combined usage of multiple device types, rapid switching between learning tasks, knowledge synthesis and multiple pedagogical models. All the features are illustrated in **Figure 3.5**.

3.5.5 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 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).

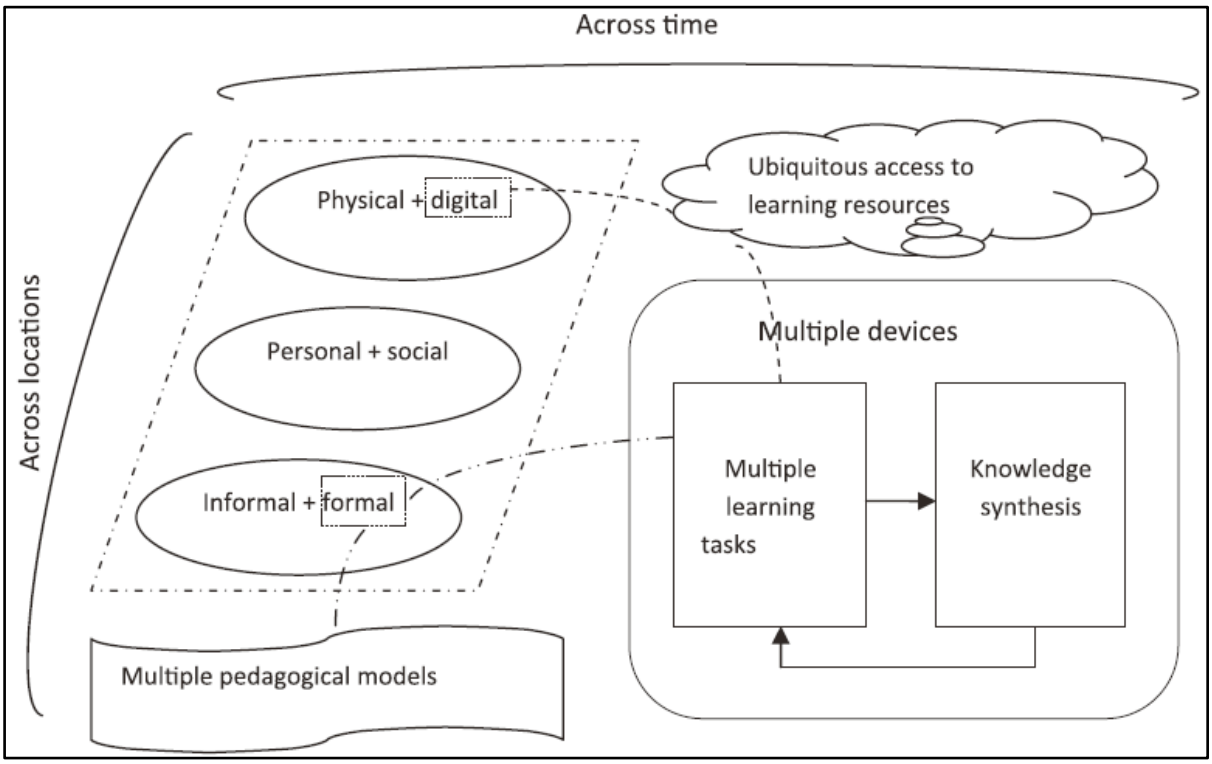


Figure 3.5: Features to support seamless learning (Wong, 2012).

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.

3.6 Results and discussion

At the end of this systematic review, a table is generated to summarize and interpret the evidences that have been found. By reflecting on the synthesized information as presented in **Table 3.1**, this study is 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 factors they are belong to. For example, S1 is for learning across spaces, times and topics by taking and applying ideas and resources.

Table 3.1: List of relevant pedagogical requirements identified for each factor based on the research questions.

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.

Research question	Task model factor	Relevant pedagogical requirements	References
		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

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

Research question	Task model factor	Relevant pedagogical requirements	References
		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.

Research question	Task model factor	Relevant pedagogical requirements	References
		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

For question 1 (What learning activities are performed and resources accessed by learners in mobile environment?), this review summarizes that learners are continually 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?), this review concludes 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 has been gained through the above review, this research project has designed a techno-pedagogical tool to support learner activities in mobile environment. It is named as MOBIlearn2 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 MOBIlearn2 application development is completed, it is packaged in .apk file and can be distributed to learners' devices as a stand-alone application. **Figure 3.6** shows the main interface of MOBIlearn2.

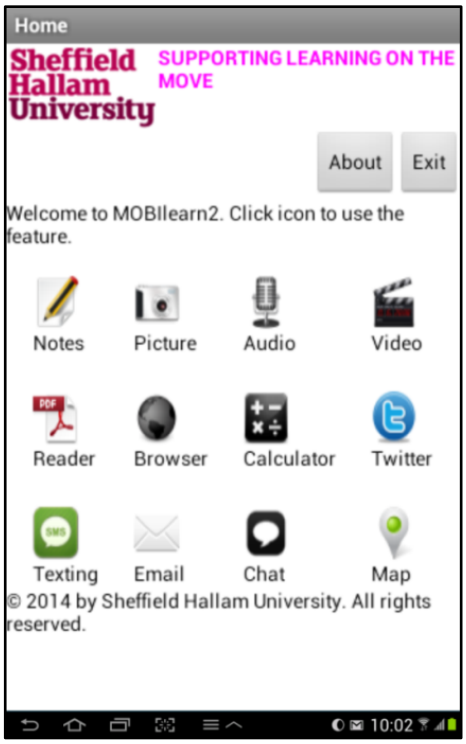


Figure 3.6: Main interface of MOBIlearn2 application

All of the components and their functionalities in the MOBIlearn2 are described in **Table 3.2**. **Table 3.2** also relates all the pedagogical requirements labelled in **Table 3.1** to each of the components of the tool that supports them.

From **Table 3.2**, it appears that the combination of MOBIlearn2 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. This research project therefore recommends this tool, as it is believed to have the capability to provide a pleasant and rich learning experience for learners either in a formal or an informal mobile setting.

Table 3.2: Components in the MOBIlearn2 application

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

Component	Functionalities	Requirements supported
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

3.7 Conclusion and future works

From this systematic review, it is 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, this review study is able to generalize 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 review study has therefore demonstrated the usefulness of the task model framework for the purpose of understanding the pedagogical needs in the mobile educational setting.

It is 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, it is 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 the study 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 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 research study must not stop here. All these requirements must be tested and validated through the MOBIlearn2 prototype in multiple 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, the case studies hopefully will reveal more complete or new requirements that will help to refine the design of MOBIlearn2 application in enhancing mobile learning experience.

3.8 Summary

In summary, the systematic review conducted in the first part of the study has successfully synthesized a set of pedagogical requirements for mobile learning from a number of published key literatures. By analysing the literature, this review study is able to provide understanding on the MOBIlearn task model and discover a common pattern of data for each of its contributing factors. The emerged patterns are structured and presented as a set of pedagogical requirement in order to be mapped with several mobile application components in an initial design of Android-based MOBIlearn2 application prototype. For instance, the requirement of taking notes is supported by *Note*, a component used for note taking.

With the findings from the systematic review, this research project is able to answer the first (What are the learning activities performed and resources accessed by learners in mobile environment?) and second (How control, context and communication can support pedagogical needs in mobile environment?) research questions as mentioned in **Section 1.4** in Chapter 1. By answering those questions, the objective O1 (To determine the pedagogical requirements for mobile learning from the MOBIlearn task model) as mentioned in **Section 1.5** in Chapter 1 has been achieved.

For the second part of study, this research project needs to validate the initial design of the MOBIlearn2 prototype by getting feedback from learners. To do so however, it is important to see how the learners experience the mobile learning with the support of the prototype in real world settings. In the next chapter, this thesis presents multiple case study as a methodology of this research project to evaluate the design and functionalities of the prototype against the identified pedagogical requirements for mobile learning.

PART TWO

CHAPTER 4

CASE STUDY METHODOLOGY

4.1 Introduction

Following the systematic review on MOBIlearn task model in the previous chapter, a list of pedagogical requirements for mobile learning had been synthesized to design an initial version of MOBIlearn2 application prototype. A prototype was developed in MIT App Inventor 2 platform for an Android-based mobile device. In order to test the design and functionalities of the prototype against the identified requirements, this research project had conducted three case studies.

In this chapter, this thesis presents case study methodology to collect empirical evidences for the research project in order to evaluate learners' experiences of using the MOBIlearn2 application prototype to support their learning activities in formal, informal and non-formal contexts (Yin, 2009).

4.2 Case study strategy

Yin (2009) has defined a case study as “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. It is widely implemented research strategy in the field of information system especially in mobile application because it can increase learning within the real world contexts, enrich collective knowledge with close scrutiny of predefined phenomena and enable the key issues to be understood (Kjeldskov & Graham, 2003). As reported by Sharples (2013), the empirical evidence from mobile learning research is mostly in the form of case studies that report the progress of a research project. For example, Churchill (2011) has demonstrated his proposed

design for mobile learning conceptual model by conducting a case study of a river (one of key topics in Geography curriculum) in Northern Thailand with a group of 72 secondary school students and two of their teachers from Hong Kong. During the field trip in February 2008, the students used HP iPAQ rw6828 Multimedia Messenger for Windows Mobile operating system to collect data, images, audio and video in order to support their river study learning task. In another study, Mor and Mogilevsky (2012) have conducted a mobile learning course using a learning design studio format. The course was conducted at the University of Haifa in spring 2012 in which the students worked in a group, engaged with core literature, identified educational challenge, conducted independent analysis and design to devise a solution and evaluated it.

Case study methodology should be used when the type of research question is *how* or *why* as the nature of the questions are more exploratory. It is also appropriate for a research study that focuses on contemporary events. Moreover, the methodology provides two additional sources of evidence, which are direct observation and interview with the human participant who involved in the events (Yin, 2009). Therefore, a case study could provide very rich data and hidden information explaining phenomena involving mobility or mobile learners' experiences in using a tool for a specific learning context (Kjeldskov & Graham, 2003). However, despite the fact that a case study enables data collection in natural setting to develop grounded-theory, it is very time- consuming and could resulting in complicated analysis.

4.3 Design of the multiple-case study

Learning with mobile devices generally can be classified into formal, informal and non-formal types of learning (Sharples, 2013). Wu et al., (2012) points out that formal learning is highly institutional, bureaucratic and curriculum driven taking place inside the

classroom or formal physical settings, whereas, informal learning is the unstructured learning that results from daily life activities related to work, family and or leisure. Some examples of informal learning are personal museum visit, reading e-book on a train and having discussion with friends either online of face-to-face. Non-formal learning could be labeled as semi-formal learning with less structured activities held outside a formal setting. The learning tends to be short term, has few if any prerequisites and the student participation are more voluntary (Crowther, 2006). Normally, it embeds inquiry activities that consider collaborative group work and problem solving such as fieldwork that helps develop observation skill and encourage students to interact with environment.

With this understanding therefore, the research project used multiple-holistic design for the case study methodology to set up three different case studies that represents formal, informal and non-formal learning contexts as illustrated by **Figure 4.1**. In addition to the analysis within each case study, this approach allowed the research project to compare and contrast findings across all cases in effort to prevent biases, add confidence to the results and support analytical generalizability (Meyer, 2001).

The multiple-case study uses non-probability sampling procedure that represents a group of sampling techniques that help researchers to select units from population that they are interested in studying. A core characteristic of non-probability sampling procedure is that samples are selected based on the subjective judgment of the researcher. In particular, the first case study adopts purposive sampling technique whilst the second and third case study adopt snowball sampling technique whereby it is used quite frequently in qualitative study (Bryman, 2012).

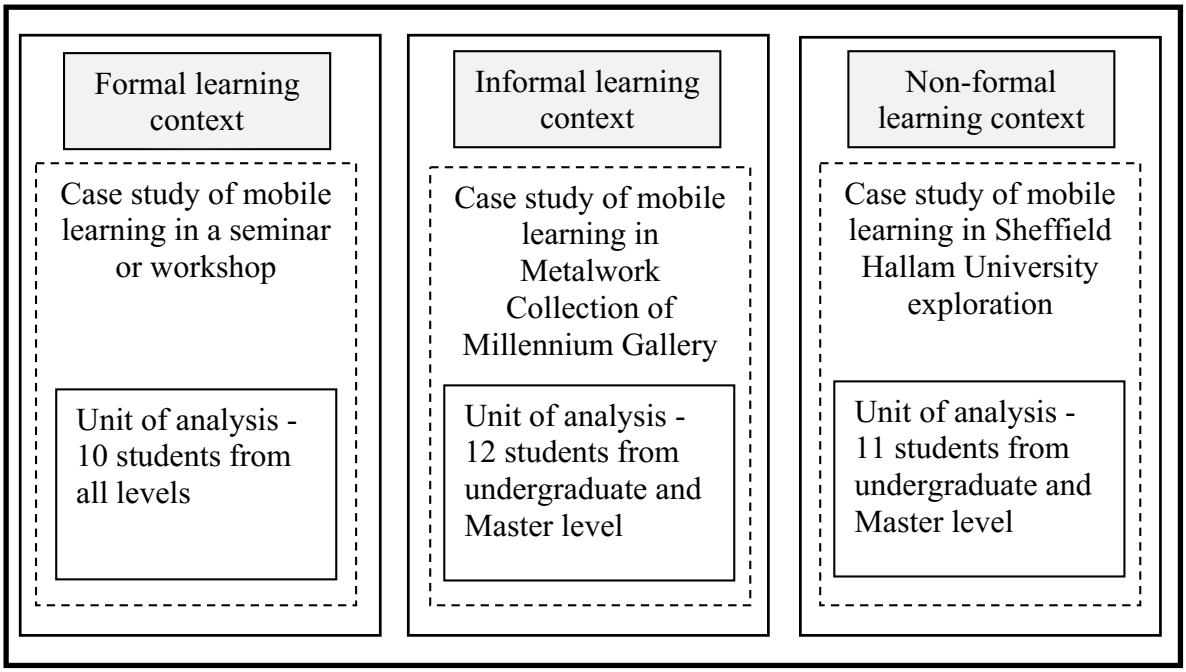


Figure 4.1: Multiple-holistic case study design for designing a mobile learning application based on MOBIlearn task model

The purposive and snowball sampling do not have many differences. In the purposive sampling, the researcher's judgment is used for selecting items or units, which they consider as representative of the population (Kothari, 2004; Bryman, 2012). Usually, the sample being investigated (e.g. people, organizations, events) is quite small. Specifically, homogenous purposive sampling that aims to achieve a homogenous sample, which shares the same traits or background, is chosen. The main goal of this technique is to focus on particular characteristics of population that are of interest in order to answer research questions. As the purposes of the first case study are to discover new ideas and to secure reactions to a new techno-pedagogical tool for mobile learning, this technique provides opinions of a targeted sample quickly.

On the other hand, snowball sampling or chain-referral sampling is a technique where a researcher begins with a small population of known individuals and expands the sample by their recommendation. In this technique, a few participants are initially recruited and then

they are asked to recommend additional participants who meet the eligibility criteria and could potentially contribute to the study to join as their group members. It is adopted in the second and third case study due to difficulty for researcher to locate and reach sample of participants even though recruitment advertisements have been made.

A total number of 33 students took part in the all of the case studies. They were from all levels of students (undergraduate, Master and PhD) with different background of courses from Sheffield Hallam University. They were identified and recruited based on the following criteria:

1. Studying at Sheffield Hallam University
2. Agree to install MOBIlearn2 prototype on their own Android-based mobile devices OR agree to borrow researcher's Android-based mobile devices to use MOBIlearn2 prototype

In order to participate in the studies, they were required to sign a consent form as shown in **Appendix A**.

Data were collected using qualitative survey and semi-structured interview for case study of formal learning context. While in case studies of informal and non-formal learning contexts, data were collected through semi-structured interview, focus group interview and field observation. The justifications for each method used are:

1. Qualitative survey

   This method allows the research project to determine the diversity of the participants' experiences in the case study. It can be used to establish meaningful dimensions and values (Jansen, 2010).

2. Semi-structured interview

This method allows the research project to get immediate contact with raw data, adjust questions to suit interviewee for providing more detailed data and quickly to complete the collection process. The interview mostly includes demographic, knowledge, experience or behavioural and values questions to ensure richness of data (Bryman, 2012).

3. Focus group interview

This method could provide information about a range of ideas and perceptions that individuals have about certain issues, as well as illuminating the different perspectives between groups of individuals (Rabiee, 2004).

4. Field observation

As this research project is concerned with the contemporary events that are focusing on human interpretations and meanings, it is necessary to examine the social reality and subjective meanings held by participants by observing what is significant and important to them. Field observation provides an opportunity for the researcher to observe directly what is happening in the social setting, interact with participants and involve in the activities. Furthermore, it provides insight into the behaviour that goes unreported and gives the researcher an opportunity to get direct experience of the phenomena being studied.

The raw data could be found online at http://shurda.shu.ac.uk/86/.

To analyse the data, this research project used thematic analysis as demonstrated by Braun and Clarke (2006) and Marshall and Rossman (1999) where textual accounts of qualitative survey, interviews and observational field notes are searched and coded for common themes and regularities. It is a type of qualitative analysis and used to analyse classifications and present themes (patterns) that related to the data. It is most appropriate for any study to discover meaning from interpretations as it uses systematic technique to associate an analysis of the frequency of a theme with one of the whole content (Alhojailan, 2012).

Further explanations and details are presented when describing each case study in the next sections. The sections then are followed by validation strategies and a summary of the chapter.

4.4 Formal learning context - Mobile learning in a seminar or workshop: A case study for evaluating MOBIlearn2 basic components and their application

In the first case study, this research project evaluated the basic components of MOBIlearn2 prototype, which are *Note*, *Picture*, *Audio* and *Video* that appears to be very essential for supporting mobile learners in formal learning activities as shown in **Figure 4.2**. This initial design was developed based on **Table 3.1** and **Table 3.2** as discussed in the previous chapter.

The objective of this case study was primarily to test the components in order to make sure all the available functions were working. For that purpose, this case study attempted to find run-time errors or any issue relating to those certain functions in an effort to improve this version of the prototype. In addition, this case study also aimed to get comments and suggestions from the participants on how to enhance the prototype in order to support their learning better.

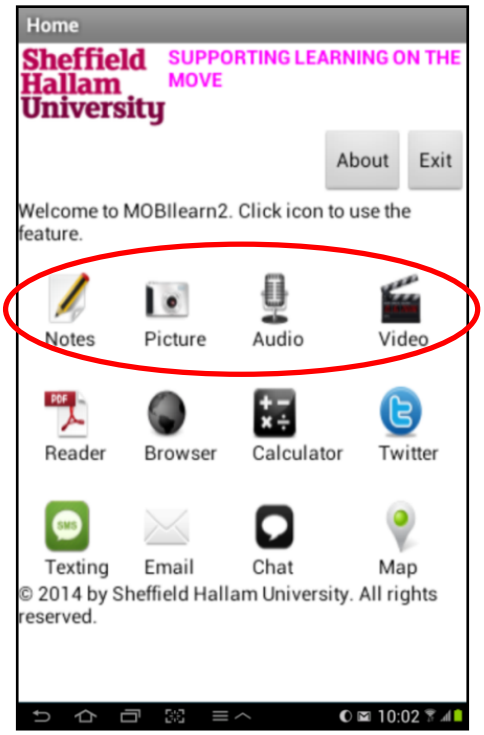
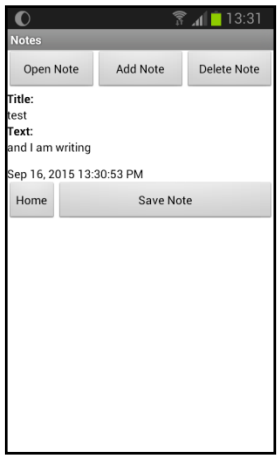
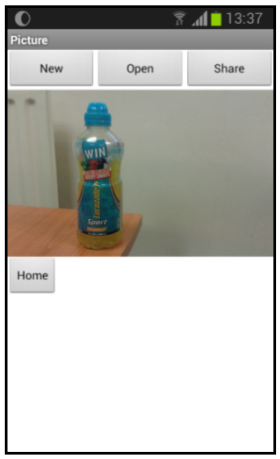


Figure 4.2: The components of MOBIlearn2 that were being investigated in this study

Figure 4.3 shows four screens representing the main interface of all the basic components of the prototype. By using the *Note* component, learners could write and save note into the device storage. They could also save it into .txt files. The note could be opened, edited and shared with friends (**Figure 4.3a**). The *Picture* component provided the learners with the ability to take a new picture, to share it with peers and to save it into device storage. They also could pick a saved picture from gallery to display it on the screen (**Figure 4.3b**). Meanwhile, the *Audio* component enabled the learners to record, play, and share audio files with friends (**Figure 4.3c**). The recorded files would be displayed in a list and could be deleted if needed. With the *Video* component, the learners could capture, play, share and delete video files (**Figure 4.3d**). The recorded video files would be displayed in a list to provide easy access for the learners if they wanted to play it back.

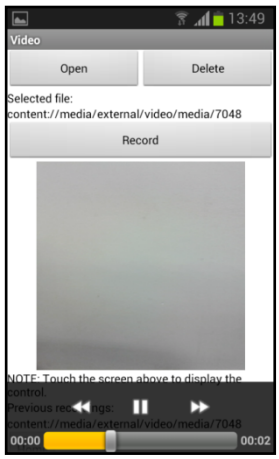


a) Note screen



b) Picture screen

c) Audio screen



d) Video screen

Figure 4.3: Main screens for each of the basic components in MOBIlearn2

To meet all the objectives, this case study was designed to allow learners to bring their own mobile devices to a seminar or workshop of their choice. In this way, the study was able to test the prototype that was running on most recent versions of Android platform and a variety of mobile devices as used by them for their learning in a contextual formal setting. The questionnaire and interview questions were also reviewed in order to prepare for future bigger case studies.

4.4.1 Recruitment of participants

The sample consisted of students from different levels of study at Sheffield Hallam University. A total of 10 student participants took part in this case study. They were currently enrolled on a diverse range of courses or fields (film study, material science, design, culture, communication and media, pharmacology and biotechnology, finance and investment, international business management, nursing and business studies).

Before the case study began, all the participants were briefed on how to use the app and the study objectives were explained. They were free to use any basic component in the app they liked or needed in order to support their learning activities in attending one-hour seminar or workshop of their choice. They were also encouraged to take notes and pictures as well as record audio and video using the tools during the event (seminar or workshop), to capture their learning moments and data, which they believe were useful for reflection and revision.

4.4.2 Data collection methods

At the end of the case study, each participant was given a questionnaire to get his or her feedback on using the app in that learning event. As presented in **Appendix B**, questionnaire consists of two parts. Part 1 asked about personal information of the participants and Part 2 asked about what components that the participants had used, the errors found and their perception of usefulness of the components. At the end of Part 2 section, participants were free to give their overall comments on or suggestions to improve the prototype.

In addition to questionnaires, three students were selected for interview in order to get deeper understanding of their learning experiences. The interview questions are shown in

Appendix C. The interviews were recorded by using audio recorder app installed on smart phone to make sure there was no any point missed.

4.4.3 Data analysis technique

The qualitative data gathered from the instruments (questionnaire and interview) were analyzed based on thematic approach that begins with identifying key points then marking with separate codes for categorization (Braun & Clarke, 2006). Each code was generated based on each basic component in the MOBIlearn2 prototype (*Note*, *Picture*, *Audio*, *Video*). All the codes were examined to find meaning from the emerged themes in order to achieve the objectives of the case study, which have been mentioned previously. All the responses obtained are presented in Chapter 5 and used to refine the features and functionalities of the prototype as well as to assess the suitability of the data collection instruments used.

4.5 Informal learning context - Improving design and functionalities of MOBIlearn2 application: A case study of mobile learning in Metalwork Collection of Millennium Gallery

The second case study was conducted to evaluate and improve the design and functionalities of MOBIlearn2 application **(Fig. 4.4)**, which had been developed based on the findings of systematic review as discussed in Chapter 3 in effort to support students' learning activities across settings including informal context. To meet this objective, Metalwork Collection exhibition in Sheffield Millennium Gallery was chosen for the study, as it provided an appropriate authentic informal learning environment for students and it was located near Sheffield Hallam University. "The gallery contains 13,000 items mostly in the form of cutlery, flatware and tableware that have made Sheffield famous, as well as beautiful

objects collected from every continent" (www.museums-sheffield.org.uk). The research questions guiding this case study were:

1. How does MOBIlearn2 app supports students to learn in a gallery visit?

This question assessed and evaluated the current version of the app used by participants to suit their needs to learn in an informal setting and examined the advantages of each feature used.

2. What improvements can be made on the MOBIlearn2 app in order to better support the students learning in a gallery?

This question attempted to discover errors and find any issue in the app in order to enhance the participants' experiences for their learning. It also tried to identify new requirements or any modification needed on each component so that it would be more suitable and supportive for informal learning.

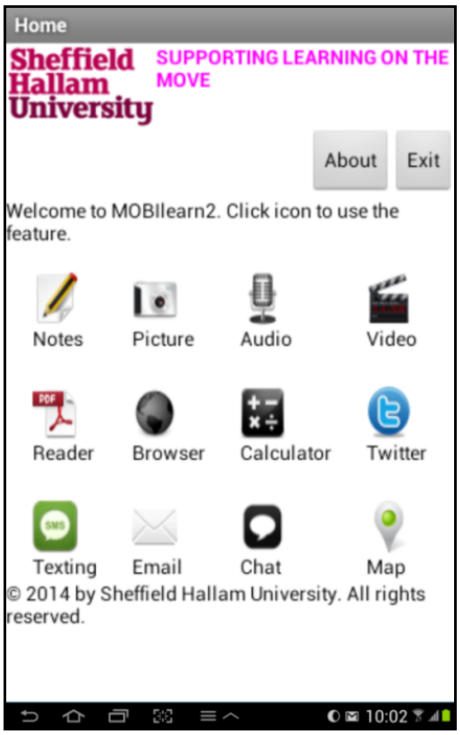


Figure 4.4: MOBIlearn2 application for case study of informal learning context

4.5.1 Recruitment of participants

From October 2015 to February 2016, 12 participants who took part in this case study had been provided with the MOBIlearn2 application running on their mobile devices. The study also provided three mobile devices (two smart phones and a tablet) for them in case they preferred not to use their own devices for personal reasons. Due to limited time and lack of resources, it was believed that this sample was sufficient as it provided meaning from data and in-depth inquiry in naturalistic setting (Patton, 1990). As the space in the exhibition was not to accommodate all of them at the same time to do the task comfortably, they were placed into three equal groups of four according to their course level and background. The first group (Group A) represented students from design-based courses such as Product Design and Interior Design, while the second group (Group B) represented students from diverse courses (Forensic Accounting, Biotechnology, Architecture). The last group (Group C) represented undergraduate students also from diverse courses (Accounting and Finance, Business Studies). This allowed the study to determine if there were any difference experiences of using the application between the groups. **Figure 4.5** show some of participants used their mobile devices to collect data and information during the visit.

Prior to the visit, participants were asked to learn about the items displayed in an hour with the support of the application and to present one of the best items that they found to their peers when they returned. During the visit, they were free to walk around the gallery, inspecting the metal works displayed, and use the application to collect and record data and information about the objects. Following the visit, each of the participants was asked to talk about the item that he or she found interesting in the gallery to his or her friends for 5 to 10 minutes.

Figure 4.5: Some of participants seen collecting information of exhibits during the visit (Metalwork Collection, Millennium Gallery, courtesy Museum Sheffield).

4.5.2 Data collection methods

Data was collected through semi-structured interviews and field observation. The participants were interviewed in a focus group session separately. The interviews were recorded on a mobile device using audio recorder application and transcribed into text. As presented in **Appendix D**, the interview questions were focusing on the two research questions mentioned previously. Specifically, they were asked:

- what features they used during the visit and why they used them
- what useful features they believe can support their learning in gallery
- what errors or issues they encountered

- about interface design of the app
- how to improve the app for better version.

Observational field notes were created during the gallery visit. The notes were analyzed and then compared with the interview transcripts to identify commonalities and patterns.

4.5.3 Data analysis technique

To analyze data, this case study used thematic analysis (Braun & Clarke, 2006) as follow:

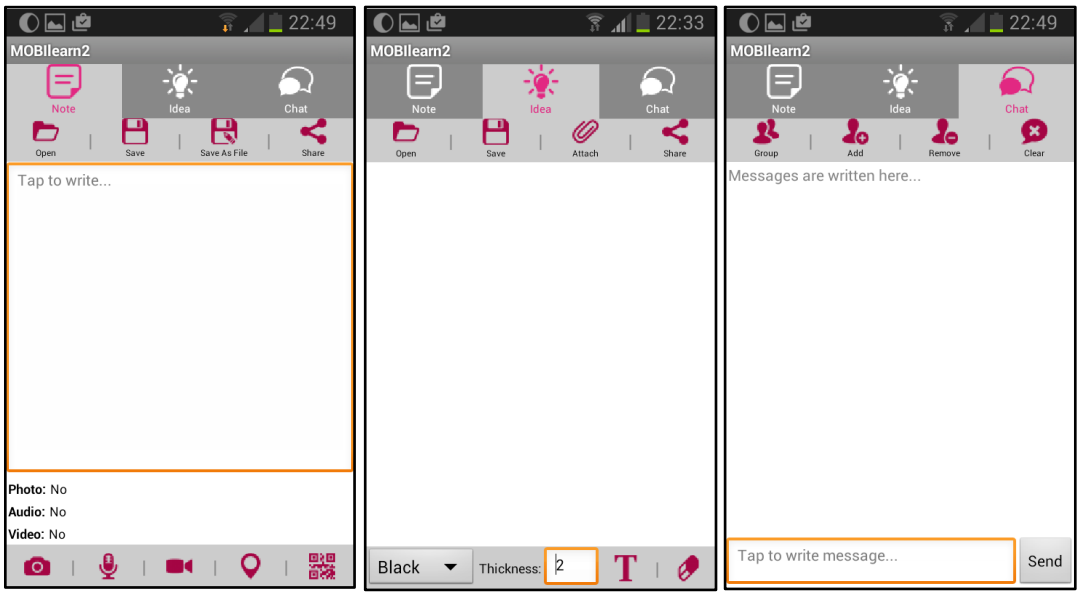
1. Familiarization with the data - The data from semi-structured interviews for each group (Group A, B and C) and observational field notes were transcribed into texts. The data were read a number of times in order to properly organize the data and get broader understanding of the data set.
2. Generating initial codes - During reading, the data were coded based on the five interview questions for each group. These pre-selected categories of question form the basis for the patterning of the data. The study then collated all relevant data with the code in tabular form for further stages.
3. Searching for themes - The study then examined the data tables to identify significant patterns and meanings. Each theme is coded with different color to allow a quick visual way to identify the themes in the data.
4. Reviewing themes – This study refined, split, combined and discarded the data and then checked them to make sure they have connections and relationships.
5. Defining and naming themes – This study conducted a detailed analysis on each theme and described what aspects of the data were being captured and described

what was interesting about the data. In this stage a theoretical construct is developed to establish the identified themes.

6. Producing the report – This study reassembled all the meaningful themes and data extracts to understand what was going on within the data and contextualized the analysis and discussion to the existing literature.

4.6 Non-formal learning context - Final design of MOBIlearn2 application: A case study of exploring Sheffield Hallam University

This case study was designed based on a learning scenario to explore Sheffield Hallam University using the MOBIlearn2 prototype to support the participants' learning activities, communications and collaborations in mobile environment. The prototype had been modified and updated from its original version based on participants' feedback in the previous case studies. In addition to that, a toolbar was created on top of screen to pin the main components. **Figure 4.6** shows several snapshots of the MOBIlearn2 prototype for the latest version.



(a) (b) (c)

Figure 4.6: (a) *Note* screen (b) *Idea* screen (c) *Chat* screen

In *Note*, learners could take notes and save it in their phone storage for future reference. They also could save it as a text file and share it with their peers through other applications such as *Gmail* and *WhatsApp*. In *Idea*, learners could sketch or draw their idea and save it to be reviewed and shared with friends. Additionally in the current version, learners also could communicate and discuss about their tasks with each other in *Chat* component.

The case study attempted to evaluate learner's experience on using the prototype for non-formal learning activities. The research questions guiding the study were:

1. How MOBIlearn2 app can support students to learn in exploring Sheffield Hallam University?

   This question assessed and evaluated the current version of the app used by participants to suit their needs to learn in exploring a place and examined the advantages of each feature used.

2. How MOBIlearn2 app can be improved in order to better support students to learn in non-formal learning activities?

   This question attempted to discover errors and find any issue in the app in order to enhance the participants' experiences for their learning. It also tried to identify new requirements or any modification needed on each component so that it would be more suitable and supportive for non-formal learning.

4.6.1 Recruitment of participants

From July 2016 to September 2016, a total of 11 students had been identified through snowball sampling. They were grouped according to how long they had been in the university. Group A consisted of 3 students who came in January 2016 (6 months) whilst

Group B consisted of 4 students who came in June 2016 (2 months). Group C consisted of 4 newest students who had just registered in September 2016. They had been provided with the MOBIlearn2 application running on their mobile devices. The researcher also provided three mobile devices (two smart phones and a tablet) for them in case they preferred not to use their own devices due to personal reasons.

Before the case study began, the participants signed a consent form as presented in **Appendix E.** Then, they were briefed about the application features and its advantages. They were also explained on a set of tasks and activities that they need to perform with the application to support their learning in the exploration. **Table 4.1** shows the list of tasks that need to be completed by them.

The participants were encouraged to test the application without restrictions for approximately 1 hour both in and out of university building. In the exploration, the participants had to visit several important locations in the university such as Adsetts Learning Centre and HUBS in order to complete the tasks given. At the same time, the researcher conducted direct observation to record participants' experiences and got involved if there was a need for help. After the exploration had completed, each participant needed present what he or she had found to his or her group for about 3 - 4 minutes. Finally, they were interviewed in a focus group session. The feedback from this study was used to feed into the final stage of the app design.

Table 4.1: List of tasks that need to be completed during the case study of Sheffield Hallam University exploration

No.	Task to be completed
1.	List 3 drinks that can be found in Atrium and Heartspace cafés with their prices respectively
2.	Explain about the unique structure of the HUBs and activities that be done there
3.	Create instructions on how to print a document using the printers in Adsetts Learning Centre
4.	Create instruction on how to go to the Reception Desk area in Cantor building from the university main reception

4.6.2 Data collection methods

This case study conducted focus group interviews (Krueger & Casey, 2008) as its purposes were not only the participants telling about their experiences, but also to give them an opportunity to share their views with their peers. Three participants of Group A, four participants of Group B and four participants of Group C were recruited to join in three different interview sessions respectively. To record the data in the discussion, notes were taken and audio recorder application was used in the interviews.

At the beginning, the interviewer welcomed the participants and briefed about the purpose of the study. The interviewer then proceeded with the open-ended questions as presented in **Appendix F**. One participant talked at one time using round robin arrangement so that all of them were given equal opportunity. The interviewer also observed for other clues or factors such as passionate comments, body language, head nods, physical excitement and eye contacts between participants that indicate level of agreement, support or interest.

Before ending the interviews, the interviewer reviewed the answer and sought confirmation with the participants to make sure that any important points were not missed.

In addition to the focus group interviews, the study also made direct observational field notes. The notes were analyzed and then compared with the interview transcripts to make sure that the points were supporting each other.

4.6.3 Data analysis technique

For each of the focus group interview, the case study used thematic analysis (Marshall & Rossman, 1999) to identify themes, hunches, interpretations, and ideas. Specifically, the study used the following steps:

1. Organize the data - The recorded audio files were listened, observational field notes were reviewed and the transcripts from group interviews were read a number of times in order to get familiar with them and get the overall understanding.
2. Generate categories of themes - The study used objective strategy that is based on prior or pre-selected category. The categories are identified based on the tasks assigned to each group of the participants. For each category, themes are identified from each interview question.
3. Code the data – The study applied a set of identified themes for each category to the data by writing the code along the passage that reflects a particular theme with different colour to have a quick visual way.
4. Test emergent understandings of data - In this stage, a theoretical construct was developed to get a sense of what the data means and challenge emergent understanding.

5. Search alternative explanations of data - Alternative understanding of the data was sought by comparing and contrasting them in each focus group.

6. Write the report - The findings were described according to the categories of task. In each task, themes were presented with amplifying quotes to illustrate.

4.7 Validation strategies

To ensure the study's validity and reliability, a strategy was used known as *triangulation* (Merriam, 2009). Two types of triangulation were used in this study: the use of multiple methods and multiple sources of data. In using multiple methods, this research project employed the questionnaire and semi-structured interviews in the first case study, focus group interviews and direct observational notes in the second and last case studies to compare data from different participants. In using multiple sources of data, this research project included multiple viewpoints and compared the data between interviewees within and across the groups.

Another important strategy was multi-case approach that could provide greater confidence and certainty in research findings. This approach allowed the research project to replicate the findings from one case study to another and validate the stability of constructs across situations (Leonard-Barton, 1990).

4.8 Summary

Case study methodology had been chosen as a methodology for this research project in order to evaluate learners' experiences of using the MOBIlearn2 application to support their learning activities across contexts. The methodology had been justified for its

implementation in this chapter to achieve the second objective of the project as mentioned in **Section 1.5** of Chapter 1.

A multi-case study design had been implemented to set up three separated case studies to represent formal, informal and non-formal mobile learning contexts in effort to collect data and feedback from a total number of 33 students from Sheffield Hallam University who voluntarily took part in the study as the participants. The case study for formal learning used the scenario of mobile learning in a seminar or workshop to discover any issue on the prototype functionalities and review the data collection instruments, whilst informal learning case study was set up in Metalwork Collection of Millennium Gallery in order to investigate how the MOBIlearn2 prototype supported the learning activities in a gallery visit. Non-formal learning case study was conducted to evaluate the prototype in supporting the new students to explore several locations in the university by completing a set of tasks collaboratively.

Qualitative survey, semi-structured interview, focus group interview and field observation had been employed as data collection methods throughout the case studies. For data analysis, thematic analysis was used on the data collected. To validate the findings, *triangulation* and multi-case strategies were implemented. In the next chapter, results and findings of the first case study for formal leaning context will be presented.

CHAPTER 5

RESULTS AND DISCUSSION OF CASE STUDY FOR FORMAL LEARNING

5.1 Introduction

This chapter presents the results and discussion for the first case study, which is mobile learning in a workshop or seminar. Most of the work in the chapter has been published in Bulletin of the IEEE Technical Committee on Learning Technology (Jalil, Beer & Crowther, 2015b). The chapter begins with demography information, and followed by presentation of data collected from questionnaire and semi-structured interview. Later, discussion, conclusion and summary are presented at the end of the chapter.

5.2 Demography

All the participants completed a seminar or workshop of their choice successfully. The general demographic picture shows:

- Gender: 7 (70%) are female and 3 (30%) are male
- Age: 5 (50%) are aged 18-30 and 5 (50%) are aged 31-40
- Study level: 2 Undergraduates, 3 Master students and 5 PhD students
- Device used: 1 Sony Experia J; 3 Samsung Galaxy Mini S3; 1 Samsung Galaxy S3; 1 Samsung Galaxy S4; 1 Samsung Galaxy S4 Mini; 1 Samsung Galaxy Note 10 and 1 Galaxy Tab 2, 1 Motorola Moto E 2

From the data, most of the participants are female students who own Samsung mobile phones.

5.3 Data from questionnaire

From the results, it is found that half of them have used more than one component as shown in **Table 5.1**. This finding shows that the learners prefer a variety of tools that they can choose from depends on what they perceive useful at a certain time in learning environment. Furthermore, the learners prefer to have different kind of materials as their learning resources as well.

Figure 5.1 presents the questionnaire results on each component. It is evident from the results that many participants have used *Note* and *Audio* components as well as *Picture*. According to the figure, there are 6 (60%) participants who take notes and record audio when collecting data or information and 5 (50%) of them who take picture when attending the event. Only 1 (10%) participant records video using the app. The use of the tools has demonstrated the suitability of the application to support learning activities in the event.

Table 5.1: Components used when attending a seminar or workshop

Components in MOBIlearn2				**No. of Participants**
Note	**Picture**	**Audio**	**Video**	
√		√		2
	√	√		1
√	√	√		1
√	√	√	√	1
√				2
	√			2
		√		1
Total				10

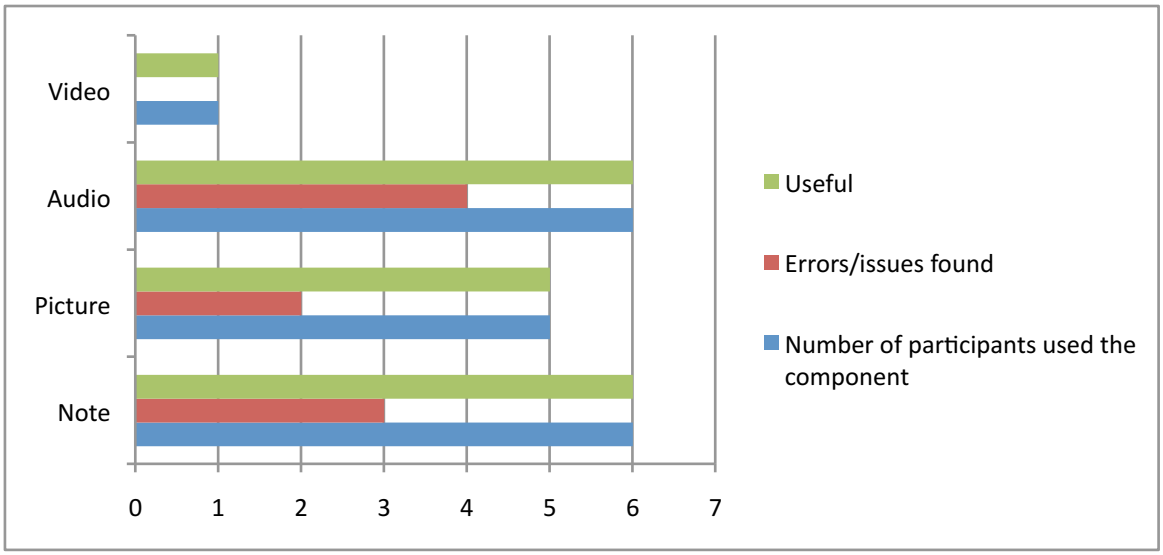


Figure 5.1: Number of participants, errors/issues and usefulness perception on each of component of MOBIlearn2.

A further question has been asked in the questionnaire to find out any error or issue that they have faced when using the tool during the event. The errors or issues stated by them are specifically presented in **Table 5.2** based on each component:

Table 5.2: List of errors or issues found by participants on each component

Component	**Error/Issue**
Note	1. hard to type note on small keyboard
	2. typing note sometimes could not catch up with lecture speed
	3. might lead to misspelling
Picture	1. could not zoom in/out
	2. could not add simple note to image
Audio	1. need to show time of current recording process
	2. could not rename file
	3. could not view list of recorded audio files
	4. add functions to play, pause and stop audio files

When asked about their perception on the usefulness of each component for their learning, they are all agreed (100%) that the components that they have used are very useful especially to collect data and information during the activity. This perception is supported by

the reasons that they have given on each of the components. For example, one of the participants has stated that the *Picture* component is very useful because of it can be used to take picture of presentation slides given by instructor and thus could save her a lot of times as she does not have to write. The *Audio* component is perceived in the same way. Two of the participants believed that the component is very useful to recall data and facts provided by their instructors during the seminar. Additionally, one participant has stated that she could go out for a while (to washroom) without any worry of information loss as she could leave her mobile to record when she is not there. She has added that she could play the recorded audio file when she gets back to her room to catch up on the lesson.

The last part of questionnaire is an open-ended question where the participants could leave their overall comments or suggestions. Generally, most of the participants are very positive in their feedback on using the MOBIlearn2 tool. They have pointed out that it is very efficient when using the tool for data or information gathering as it combines many useful features and provides more different kind of learning sources and data for revision and reflection. Furthermore, they could switch between features and tasks easily if needed. In spite of having such advantages, they have also commented on several issues as outlined in the **Table 5.2** previously. Equally important, one of them has suggested providing text-to-speech and speech recognition functions to support note-taking activity.

5.4 Data from semi-structured interviews

Three participants were selected for semi-structured interviews in order to get more insight about the use of the MOBIlearn2 tool and how to refine it. First question is about on how generally they used the tool in the event. Two participants have said that before the seminar started, they asked permission from the instructors first to use their mobile devices to

collect data and information and got their consent verbally. Once it is allowed, they put their devices on table and launched the application. On the other hand, the third participant has said that she did not mention about using the tool to her instructor. However, her instructor did not mind when she was about to take image on the slides presented in the seminar room. During the seminar, two participants have reported that they used more than one components of their choice (one participant used *Note*, *Picture* and *Audio* and another one used *Note*, *Picture*, *Audio* and *Video*). Only one participant has chosen to use *Audio* as she planned to store audio files in her device in order to listen it again for revision. Fortunately, all of the interviewees have not had difficulties with the interface of the tool, as they are familiar with the Android graphical components.

The second question is asked to detect any errors and issues from the tool. The two of the interviewees have reported that they had issues with the *Note* component. They have added that it is difficult to write and type using the small virtual keyboard provided by their devices.

> Student A: *"It's hard for me to catch up with the speed of lecturer's speech when using the small virtual keypad provided by my device. So, sometimes I took pictures instead of writing…but I believe I don't have problem if I use it in my field work as there is no time constraint"*.

> Student C: *"I think that I am not fast enough to use the keyboard in my phone…but if the keyboard is quite big like in an iPad…I think it's ok"*.

For *Picture* component, one of the interviewee has reported that she could not find a way to insert note on the images taken and the other interviewee has said that he could not zoom in the picture taken in order to read notes on it.

Student B: *"When I stretched the saved image, I could not read the texts on slide as it became a blur…so, I think this feature needs to have zoom in and out functions…if possible"*.

Regarding the *Audio*, most of the interviewees claimed that there is no issue on that component but one interviewee has stated that she could not make sure the recording process is success as she could not view the list of recorded files. On *Video* component, one of the interviewees has reported that the video captured during on the seminar is not clear enough. Therefore he has proposed that those who want to use it need to adjust the brightness in the setting in order to suit with the lighting conditions in the environment.

Third question is "What features or functions that you think are very helpful for your learning in the event?" All of the interviewees have indicated that features of taking notes (*Note*), taking pictures (*Picture*) and recording audio notes (*Audio*) are very helpful for them to do revision on the lesson during their free time. Only one of them has added that recording video (*Video*) is also useful as he can capture the entire details of the situation in the learning place and store it as his personal record.

The purpose of the last question is to get the interviewees' comments and suggestions in order to improve the tool for supporting learning activities in that kind of event. One of the interviewee has pointed out that by using the tool it is easy to switch multiple tasks as the design has integrated all required components and thus learners do not need to use different app for different tasks.

Student A: *"I think this tool is good for brainstorming or take notes of idea emerged when I am on the move…anytime. So, I think it is better if you include a mind map application.*"

In addition to mind map application, she has also suggested finding a way to transfer all files into computer when storage card in the device is full. This suggestion is quite similar with the second interviewee who has suggested finding a way to do backup properly (could automatically export data in phone to PC). The last interviewee has pointed out that the tool is very useful to all research students as it can assist them in their study.

> Student B: *"I recommend this tool to research students in my area…ethnography...as all the features I have found such as taking pictures, videos and notes are suitable for our research works…"*

5.5 Discussion

This research uses non-probability sampling procedure that has resulted in the subjective judgment of researchers in selecting the respondents. Even though the researchers attempt to cover all different level of study of the participants in the university, this sample and demographic profile are not representative of student population in general. The results therefore primarily indicate diverse behaviour and interest. Whilst this is appropriate for a qualitative study seeking feedback on a phenomenon as mentioned by Bryman (2012), it is not suggested that the quantitative data would be replicated in a similar study.

Comparatively, it appears that most of the qualitative data from questionnaire and interviews are supporting each other. Even so, the data from interviews are quite richer and provides deeper insight on each issue found or suggestion made. For example, one of the participants has come out with a positive suggestion to include a mind map application as a brainstorming tool in the interview. This finding hence shows that it is essential to take into account the context of use, which can have important influence on the design, and use of the product in future.

From the findings, this case study has confirmed that most of the features in the basic components of MOBIlearn2 application (*Note*, *Picture*, *Audio* and *Video*) have been very useful for the students to support their learning activities. There are also several changes and improvements that have been made to the application based on the feedback in this case study as listed below:

1. For *Note* component, *Edit* button is provided to enable the users to edit their saved notes.
2. For *Picture* component, functions to zoom in and out are added to enable the users to read small text on the saved pictures. A function to add text on picture is also added in order to provide the users with the capability to annotate the picture.
3. For *Audio* component, a time label to show the current recording process is displayed for the users. In addition, a function to rename the saved audio file is provided. To enable the users to view a list of recorded files, a button is added to open the list from the device storage. Moreover, functions to play an audio file and to pause and stop a currently playing audio are provided to give control to the users when using this component.

Although the learning setting is quite formal, they are efficiently and effectively use their mobile devices to collect data and information as their learning resources. Nevertheless, this usage of the mobile in formal learning setting should get permission or consent from the instructors first.

Another key point from this case study is all the participants have not had any usability issue when using the tool for the event even though they have used devices from different kind of models or manufactures. It is believed that this is due to several reasons. Firstly, they are all familiar with most of the components in the application, as the study has

used the standard Android GUI components in its design. In addition to this, it seems that they can tolerate with their devices attributes or capabilities of the hardware that they are currently using. Although this may be true, these assumptions need to be empirically investigated further.

5.6 Conclusion

In testing the functions of several basic components of MOBIlearn2 application, this case study has successfully revealed several errors and issues by getting comments and feedback from the student participants who have used it to support their learning in a seminar or workshop. As a result of this learner-centred design approach, the learners by themselves have explored and tested the tool in the real world context, reported the findings and suggested some improvements to researchers. All the errors and issues have been noted by researchers and presented in this paper so that it will be addressed when refining it in future development. This study has therefore demonstrated the advantages received when involving real learners in design stage for developing new technologies or innovations in real life environment especially for educational purposes (Camargo et al., 2012).

Evidence from this case study has been demonstrated in authentic student voices that may prompt the educators to revise infrastructural support, policies as well as data privacy concerns to allow the use of mobile devices in a seminar or workshop and encourage students to use them for learning purposes. This study also encourages the practice of 'bring your own device' (BYOD) that academic institutions could employ to embed mobile learning into mainstream education. By leveraging what students have and do, educators could combine formal, non-formal and informal learning activities to provide more effective and creative pedagogical approach in mobile environment.

5.7 Summary

In summary, MOBIlearn2 application is perceived as a useful tool for the learners to learn in a mobile formal setting such as in a workshop or seminar. Although there are some errors and issues found on the application during the case study, learners found it is very helpful as it provides them with the capability to collect data and information during their learning activities. Once the workshop or seminar is over, the data and information are stored in their devices and could be retrieved when they have free time such as at home or travel to do revision. Hence, their learning experiences are enhanced with this flexible accessibility of learning resources.

In the next chapter, the research project presents the results and findings of a case study on mobile learning in informal learning setting. All the basic components of the application, which have been proven useful in the first case study are retained and integrated with several new components.

CHAPTER 6

RESULTS AND DISCUSSION OF CASE STUDY FOR INFORMAL LEARNING

6.1 Introduction

In this chapter, this research project presents the results and discussion for the second case study, which is informal mobile learning in Metalwork Collection of Millennium Gallery in Sheffield. Most of the works presented here have been published in a conference (Jalil, Beer, Crowther, 2015c).

Using thematic analysis technique to analyse the data collected in this case study, a theoretical construct is developed based on pre-selected interview questions to present the initial codes and to get a sense of what the data means. **Figure 6.1** illustrated the initial codes that are established from the data analysis process.

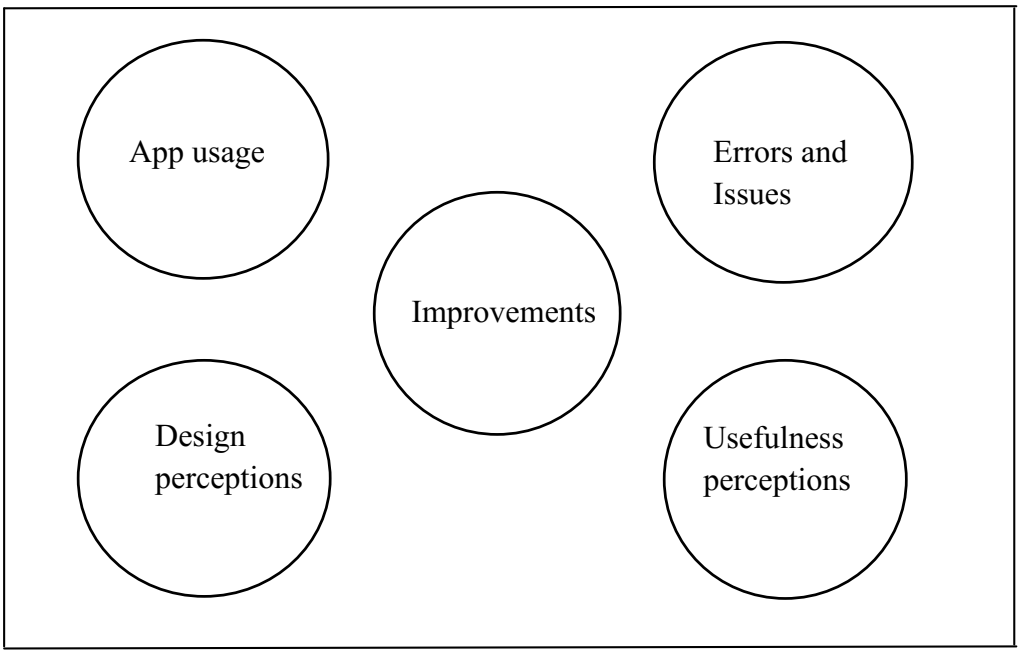


Figure 6.1: Five themes identified from the case study data

All the themes in each initial code are elaborated in details in the next sections and followed by a discussion on the MOBIlearn2 new interface design, conclusion and a summary of this chapter.

6.2 App usage and usefulness perceptions

From the results, it was found that most students were taking pictures and notes as well as recording video to collect data and information about exhibits of their interest during the visit as shown in **Figure 6.2(a)**. Specifically, there were 11 participants (91.7%) who used *Picture*, 10 participants (83.3%) who used *Note* and 6 participants (50%) who used *Video*. The main reasons given for the use was they wanted to capture the moment of the visit, save the information and recall the details clearly. Another reason given was they found that the components were simple and very convenient to be used during the visit. Based on the observation, as they walked in the gallery space to discover the most interesting item to share with friends, they kept trying to get good angle for their photo and video shots. They kept using these tools until they were satisfied with the results. Due to the silent nature of the space, most of them completed the task individually keeping their voice low in the gallery. On the other hand, only 2 students (16.7%) used *Audio* and 1 student (8.3%) used *Map*.

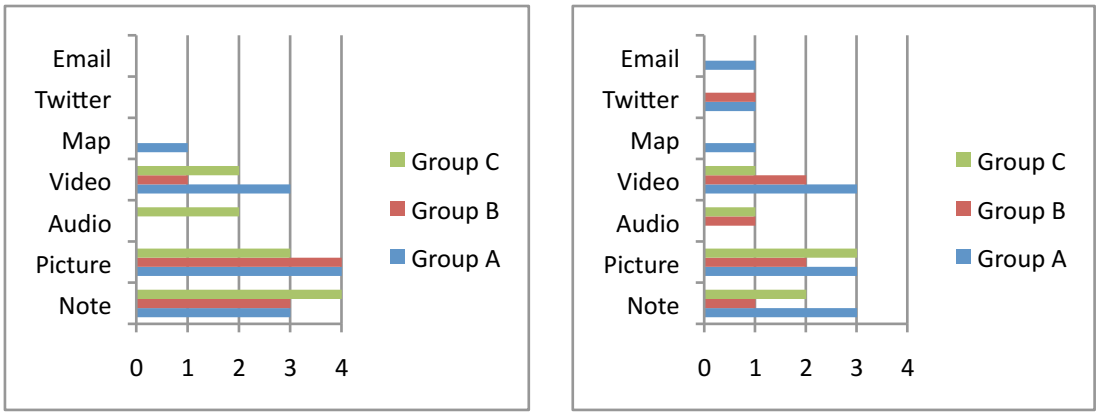


Figure 6.2: (a) Number of participants used each of components (b) Number of participants perceived the usefulness of each component

In the same way, **Figure 6.2(b)** shows that most of the students perceived that taking pictures, writing notes and recording videos were the most useful and helpful features provided by the app to help them learn in the gallery. Out of all the students who participated in this study, 8 of them (66.7%) believed that *Picture* was very useful for this kind of learning. The reason behind this was the component could be used easily and instantly as well as to capture the actual look of exhibits from different angles on site and present it with different touches and styles. This was followed by *Note* and *Video* components (50%). The most compelling evidence on *Video* came from an Interior Design student (student A) and his view was agreed by all of his friends.

> Student A: "*With Video feature, I can take 3D view of the object and present it to people more clearly and understandable…I recommend this tool for interior design students as it is very helpful for their design works*"

On the other hand, both *Audio* and *Twitter* were perceived useful by 2 students (16.7%) while *Map* and *Email* were thought useful by only 1 student (8.3%).

From the answers given, it could be said that there were no obvious differences of pattern of use and perception among the groups. All the groups preferred to use the same tools on the app and perceived them in the same way. As observed in the field, they also seemed very comfortable with the tools and valued the ease of use of the app even though they needed to perform the given task on the move and in a limited space. Furthermore, it seemed that they were already familiar with their mobile devices technology and application, as they knew about the advantages and disadvantages of using a specific tool. For example, student C pointed out that taking a picture is preferred as it uses less storage space than audio and video files.

> Student C: *"If it is in a gallery, I am sure that taking picture or basically the photographic tool is important because you can capture the actual image and shape of the items…even though taking video is ok….but it use a lot of storage in your mobile…"*

In another example, they agreed with each other during the interview that they could do many creative things with pictures or videos taken by using available photo or video editor applications available for download from online store. By doing this, they can share the materials with their friends in a more interesting way. Another key point is even though they did not use social components like *Twitter* and *Email* during the visit, some of them thought that those components were very useful to share memorable moments and experiences with their friends.

6.3 Errors and issues

Table 6.1 Errors and issues found by some participants for each group.

Groups	Errors and issues
A	1. Could not rename the video file after save it.
	2. Could not see the saved video but the sound could be heard
	3. Could not drag the saved picture to focus on a specific area
B	1. The image on the saved video didn't come out except the sound
C	1. No picture when play the saved video, but the sound could be heard
	2. Many steps to access a function

From the **Table 6.1** above, it appeared that most of the technical errors faced by all groups came out from the *Video* component. In this case, it was found that all the participants who pointed out these errors were observed using a tablet during the visit. Another finding was an issue mentioned by participants from Group A which is a function to drag a photo to focus on a specific area if it is bigger than the device screen. Even though they thought that zoom buttons provided on the app were good and effective for resizing an image, they agreed that it is worth to have dragging function which can move the image around to see the hidden part of it. Equally important, there was a design issue, which had been mentioned by participants from Group C where they thought that they needed to do too many clicks to access a function, and thus make using the app slow and prone to error.

6.4 Design perceptions

Participants were equally distributed in each group about the interface design of the app. For every group, half of them (50%) were fully satisfied with the design and another half were partially satisfied and suggested that it should be improved. As the study was concerned with the effort to provide a better design for the app, all the partially-satisfied comments were extracted for design refinement as presented by **Table 6.2** below.

Table 6.2 All partially-satisfied comments on interface design of the app from each group

Groups	**Comments**
A	1. Combine all the taking note, picture, audio and video functions as one component or put them in a place to make it easier for learner (to use them quickly)
	2. Use icons to make it more attractive
B	1. Quite confusing (e.g.: when a user wants to go back to *Home* screen after taking a picture, she accidently delete some pictures)
	2. Make simpler and easier (don't need to have many steps to do one function)
C	1. Layout is ok, but too many steps needed to use a function
	2. Combine both *Notes* and *Picture*: picture/ image are helpful to understand the notes taken.

As it appeared from the table, the participants preferred to have a simpler and easier design for the app by integrating all the features into a single component and thus, allowing quicker access to a function. This finding was supported by observation when it was found that some of the participants were spending a long time with their head down to their devices screen in order to change from one function to another. It was also believed that with a better design as suggested by them, the user could avoid unintentional errors and use the app more

efficiently. Additionally, this study found that Group A which consists of design-based students preferred more attractive and professional-look interface as they suggested that the app should use icons like other commercial apps do.

6.5 Improvements

From the last question, the study had obtained several useful comments and suggestions from the participants about improvements.

Table 6.3 Comments and suggestions raised by participants from each group to improve the app

Groups	**Comments and suggestions**
A	1. Social media applications like *Facebook* are useful to share the materials and information with friends
	2. Sketching tool could be provided
	3. Make it simple, just directly go to *Note* and access all the components, no need to have main screen
B	1. Add drawing application for art or architecture students
	2. Make the app to be more simple and easier
C	1. QR code scanner will be useful and helpful for museum visit in other places
	2. Add *Facebook* or *Instagram*.
	3. Redesign to have more attractive, sharp design, other than that it is nice

It was found that 3 comments (37.5%) were related to the design improvement. Since they were quite similar to the issues raised in the previous section (design and user friendliness), it was believed that they were needed to be resolved immediately. The remaining comments were related to new functionalities being required for the app. The new functionalities included a tool for sketching or drawing, *Facebook* or *Instagram* access to share experiences with friends and a QR code scanner. Regarding the scanner, all of the participants in Group C agreed with their friends who gave the following suggestions.

> Student B: *"I think QR code scanner should be provided because it is a useful application to be used in a gallery…"*
>
> Student D: *"If there were QR codes there, I preferred to scan them to get information popped-up on my phone screen…"*

6.6 Second evaluation for new design and functionality of MOBIlearn2 application

By resolving the issues and analysing the comments and suggestions for improvements from the participants previously, this case study conducted a second round of evaluation in order to assess for a new design and functionality of MOBIlearn2 application. **Figure 6.3** shows the new design interface of the application.

In this new design, researcher had resolved the technical errors on *Video* components on the tablet devices successfully. The new design also combined the components of *Note* with *Picture, Audio*, *Video* and *Map* to make it simpler and easier as suggested by the participants. Furthermore, a QR code scanner component was introduced in the application to provide learners to access information by scanning a QR code.

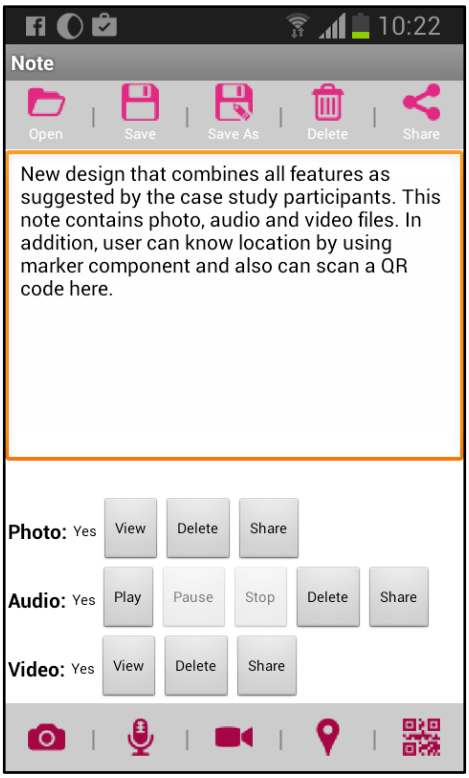


Figure 6.3: New design of MOBIlearn2 *Note* interface

Moreover, the participants were provided with the access to *Twitter*, *Facebook* and *Gmail* component by clicking on button labelled *Share* for each of resource files in order to share the materials with their friends and colleagues. **Figure 6.4** shows the options available for the participants after clicking on *Share*. As suggested by the participants, the application was also provided with a new component to sketch or draw, which is called *Idea* as shown in **Figure 6.5**.

The sample of study for the second evaluation consisted of participants from the first sample who could be reached by the researcher. They were asked to repeat the same task like they did in the first evaluation previously. As in the first visit, the researcher was also observing them to find more data. However, this time they were just asked about the design and functionality of the new version of the application in semi-structured interview. Their

answers were written in notes and analyzed by the researcher to compare with the findings of the first one.

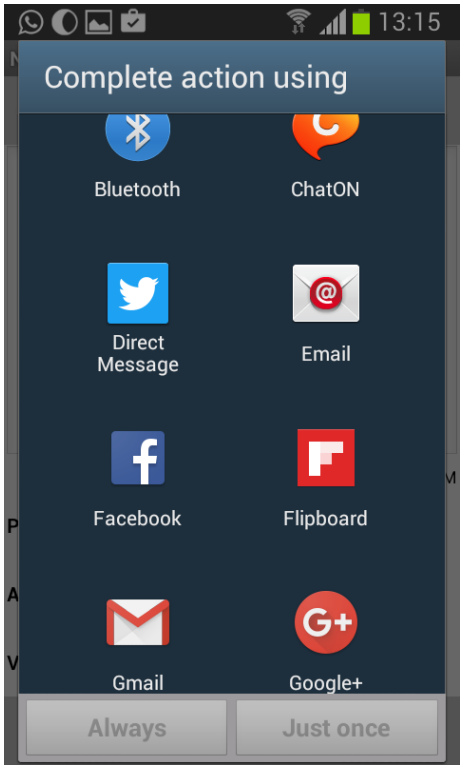


Figure 6.4: Options to share materials when button *Share* is clicked in the application.

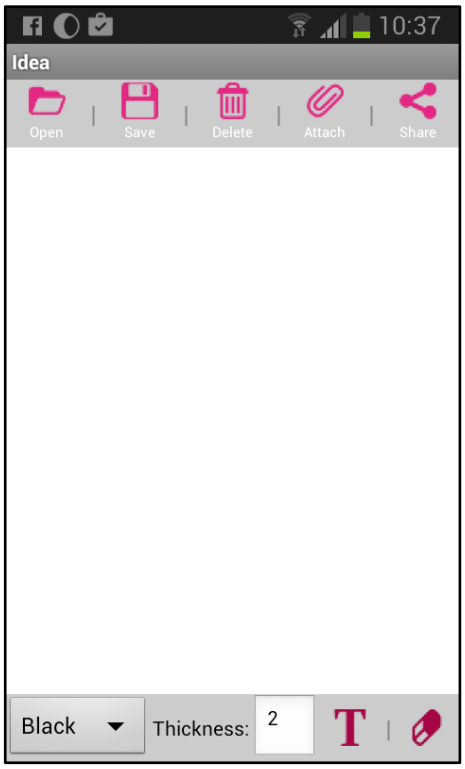


Figure 6.5: Main interface of *Idea*

6.7 Results of second evaluation

6.7.1 Design

From the second design evaluation results, it was found that all of them (100%) were fully satisfied, as they believed that the new design was much better. They had pointed out that they were able to collect data in multiple formats and access multiple resources for learning in a very convenient way. This advantage provided them with a capability to understand a note better as the note was attached with other kind of resources that help them learning better. As observed in the field, they efficiently switched from one component to another when using the app.

Most important, they found that the new design was more user-friendly and understandable. From the observation, they looked familiar with all the functions provided in the app. Some of the comments from the students are presented below.

> Student B: *"I think the new design is more user-friendly, more understandable…yea…more attractive too…and most importantly I can access all the functions quickly…"*
>
> Student H: *"User-friendly…all icons that you put into the app like Open…Save…are the ones that I can see on most computers and…Picture…Audio...you can tell the function just by looking at the icons…"*

6.7.2 Functionality

In the second round of evaluation, it was found that most of the participants were satisfied with the new functions provided by MOBIlearn2 application. They thought that QR code scanner was very useful for learning on the move, especially in the museum or gallery. To benefit from this component however, it was suggested that a QR code should be embedded in the exhibit of the gallery so that it could be used to automatically retrieve further contents such as video or a curator's talk when scanned by a mobile device. They also believed that access to social components such as *Facebook* and *Twitter* made their learning discussion with their peers more engaging and interesting.

In addition, they found that *Sketch* component was one of the important tools for their learning. It was believed that this component was really useful as taking pictures and video in some museums or art galleries were not allowed. This feature allowed learners to draw or

sketch to capture their idea using their phone in such an environment. This tool also could be used to take notes in handwritten mode using stylus if available.

6.8 Discussion

The analysis of the second evaluation results from the case study indicated that MOBIlearn2 application activates visitors' motivation by supporting their learning activity on the move and connect their learning and experience across contexts. The findings were in parallel with the findings from the first evaluation. Furthermore, it was found that the tool provides opportunities to have personalised content by letting them capture it with their own way, thus embracing a truly learner-centred approach to learning.

Significantly, the participants found that the new design and functionalities embedded in the new version of the application were really helpful and useful to learn in the museum or gallery. Similar to the findings of the first evaluation, it was observed that the application drew learners' attention to the objects or exhibits in the gallery, not distract from them. In addition, it was noticed that students were comfortable to use the application on their own device. Receiving positive feedback from this case study, the following changes and improvements had been made to the application:

1. Integrating *Picture*, *Audio*, *Video* and *Map* components within a single *Note* interface
2. Using more attractive icons instead of text label for buttons
3. Adding QR code scanner component and tool for sketching (*Idea*)
4. Providing access to *Twitter*, *Facebook* and *Gmail* to share materials

Importantly, the experience of conducting this case study helped researchers draw some valuable feedback with respect to the design of the application, because it was found that the participants prefer simple but integrated components where they could access all the functions quickly and easily. Moreover, learners could understand their notes better with the integration of different forms of information and resources. Therefore, it was believed that a seamless-as-possible interface design must be provided, as it was a really important factor for the good acceptance by users.

> Student D: *" I definitely love the idea of this application…this is the first time I use this kind of app for my visit and I found it is very interesting and useful for me"*

6.9 Conclusion

From this case study, it was confirmed that the MOBIlearn2 app offered support for mobile learners to do analysis on an exhibit, construct interpretation or meaning and share with friends, organize and present learning resources or files, have reflection and revision, generate discussion, exchange information and experiences as well as store data, information and files in many forms for further use in personalised way. To have a deeper learning, the learners could share their perspectives and experiences with their colleagues and extended their learning informally for collaborative activities using social media components provided by the app.

Additionally, the study also found several technical and design issues, which were resolved so that the learner could use the app more efficiently and effectively without any error. In particular, the design of the app was improved to have a simpler and user-friendly interface as requested by the learners so that they could learn in a more seamless and

comfortable way. Furthermore, the study obtained some feedbacks and suggestions in order to improve the functionalities of the app with the aim to provide better support for the mobile learners to enrich their learning experiences in a museum gallery.

The significance of the research outcome therefore rested on innovative design of the MOBIlearn2 application to support informal learning activities for higher educational students to learn in a contextual, situated and authentic environment. As demonstrated by this study, the students could benefit from the application in order to learn in more creative and collaborative ways during and after a gallery visit. More broadly, this study had implications for ways of improving and enhancing traditional instruction to encourage student motivation and positive achievement in certain courses for higher educational institutions. For example, a standard mobile computing course for non-computer science majors could be made interesting by adopting problem or studio based learning to allow the students to design their own tools as the basis for discussion and proposed solution.

Despite the fact that the qualitative research in this case study was specific to a particular context, time and a group of participants, the study confirmed that a well-designed and user-oriented mobile application was really important to provide better support for mobile learners to learn across contexts, spaces and time.

6.10 Summary

In this case study, learners had perceived MOBIlearn2 application useful for learning in an informal setting such in a gallery visit in spite of some technical issues found on the application. During the visit, the application had provided the learners with the tool and support to collect and store data or information about an exhibit and share it with others.

Despite the very positive and good acceptance of the participants involved, there were some design and functionality improvements need to be done in order to better support them in such environment. In response to the issues, a new design had been proposed and evaluated for the second time. In this time, all of the participants had indicated their fully satisfaction with the improvements.

In the next chapter, this research project presents the last case study, which took place in a non-formal learning context. The case study serves as the last iteration of MOBIlearn2 design process for designing mobile learning application based on the MOBIlearn task model.

CHAPTER 7

RESULTS AND FINDINGS OF CASE STUDY FOR NON-FORMAL LEARNING

7.1 Introduction

In this chapter, this research project presents the results and findings of a case study of non-formal mobile learning, which is Sheffield Hallam University exploration. This chapter is a part of the thesis structure that represents the last chapter of the second part of this research project. In particular, this chapter divides the results of the case study according to four tasks that have been performed by participants during the exploration. In each task, the results are presented in detail based on three data codes (usage, issues and design perceptions) as presented in Chapter 6 in order to provide clear explanation to reader. The other two data codes (usefulness perceptions and suggestions to improve) are used to present the results in a separate section to provide clearer picture. The section is then followed by a discussion on the findings, conclusion of the study and summary of the chapter.

7.2 Demography

The demographic information of the participants is as follows:

a) Gender: 5 (45.5%) are male and 6 (54.5%) are female

b) Age: 7 (63.6%) are aged less than 23 and 4 (36.4%) are aged more than 23

c) Study level: 7 undergraduates and 4 Master students

d) Device used: 4 Samsung Galaxy Mini S3, 3 Samsung Galaxy Tab 2, 3 DingDing SK2, 1 Samsung Galaxy S4

7.3 Task 1 - List at least 3 drinks with price that you can find in Atrium or Heartspace café

From the results, it was found that all the participants conducted the task by writing the information on *Note* text area and saving it for future retrieval. They used the component because of they thought that it was easy to record data and information as they were used to taking notes in other similar mobile applications on their mobile phones. This meant that the component was quite understandable, as they looked familiar with the most of the functions provided in the application during the exploration.

However, there was an issue that was common to the participants who used the *Note*. The small screen of the mobile phones prevented them from seeing what had been written in the text area when the built-in virtual keyboard appeared. The keyboard used most of the space on the screen and automatically hid the written texts. The issue is illustrated as in **Figure 7.1**. As observed in the field however, this was not a problem for those who used a tablet because of the larger screen size it has.

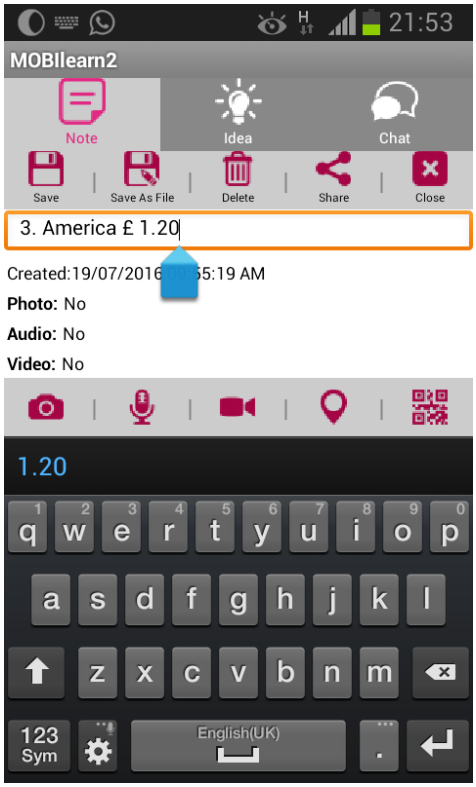


Figure 7.1: Some parts of written texts are hidden by virtual keyboard

The participants were quite confused with *Save As File* button as they did not really understand what does it mean and the purpose of using it. One of them asked whether it was to create a *.txt* file in phone storage and if so, it should be written as *Save As Text*. The other issue was that they could accidently type on the opened note as the text area was in active mode every time the saved notes were opened.

Using the *Note* to take note, most of them thought that the design of the component was user-friendly and not complicated. Despite the issues mentioned previously, they found that the GUI elements and icons used in the *Note* were suitable for the purpose of presenting the functions, as they could understand them easily. They also found that the colour used was quite nice and navigation was effortless. However, some of the participants thought that new users of the application would take longer time to explore the functions in the *Note*.

7.4 Task 2 - Describe about the unique structure of the HUBs and what activities that you can do there

Based on the results, it was found that most of the participants took a number of pictures for this task using *Picture* component. This was similar to what had been observed by the researcher in the exploration. The reasons behind this were the component was easy to use and could provide details for visual information about the HUBs. Only one of them used *Video* to create a movie or a story for the task. He mentioned that it was more convenient to record a video and present it to the audience.

There was no error on the *Picture* component. However, there was an important issue mentioned by all the participants that was to provide a function to enable a user to add more than one picture for a specific note. They thought that normally a single picture was not enough to explain a complex thing such as a building. **Figure 7.2** shows the snapshot of a picture by a participant for the task.

There was another issue for the *Video* component mentioned by the participant. He found that after for a while recording the video, he got a notification of insufficient storage space on his screen. At the same time, he thought that the application became so slow and sometimes it was not responding. Apparently, the issue was related to hardware component of his device.

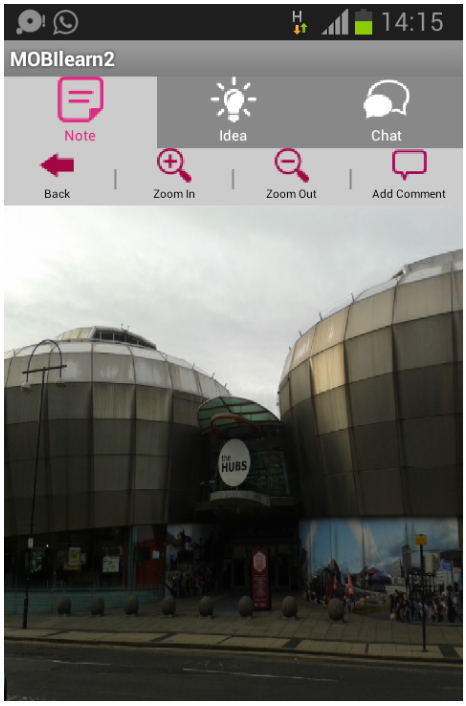


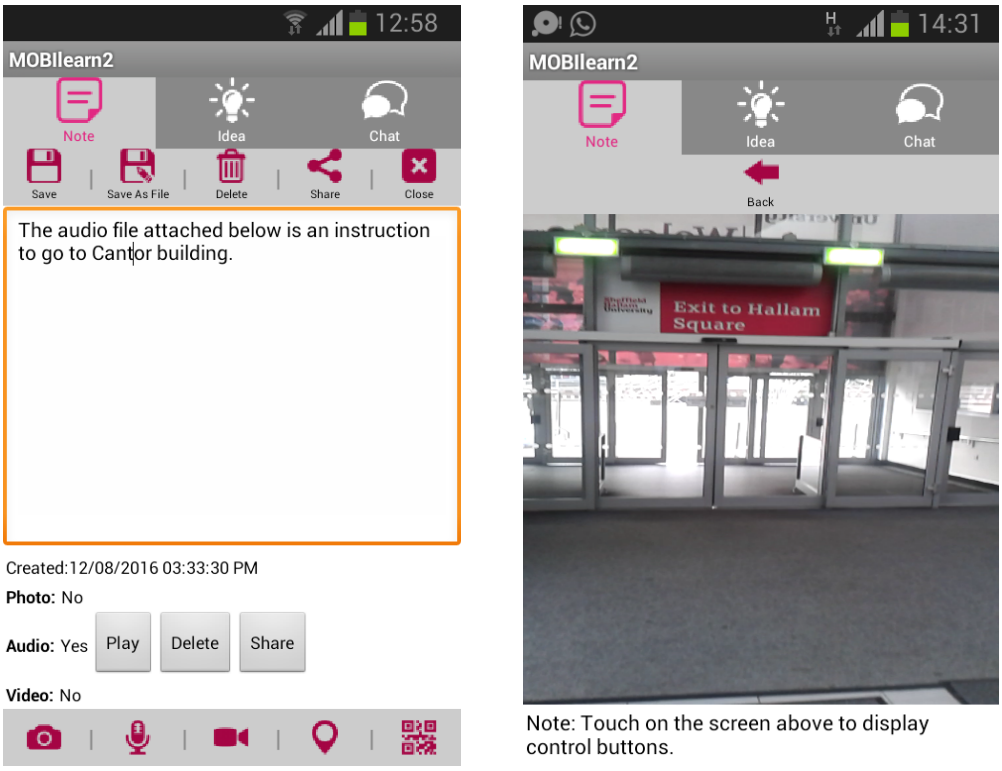
Figure 7.2: A picture of HUBs building taken by a participant using the MOBIlearn2 application

In terms of the design, all of the participants found that the *Picture* component was understandable, simple and easy to use. Navigation was really smooth and the icons used for the component were adequate in terms of style, shape and colour. They also had mentioned the same points for the *Video* component.

7.5 Task 3 - Create an instruction on how to go to Reception Desk area in Cantor building from the Main Reception in the main building

For this task, half of the participants used audio recorder (*Audio*) and another half took a video (*Video*). **Figure 7.3** shows the snapshots of the component usages. For the *Audio*, the participants mentioned easy-to-use was the main factor that influenced them to use that component. For the *Video*, the participants identified that the details of the visual

environment or road could be captured and recorded so that it could provide more information to the audiences in addition to voice.



(a) (b)

Figure 7.3: (a) audio instruction is attached (b) instruction video is playing

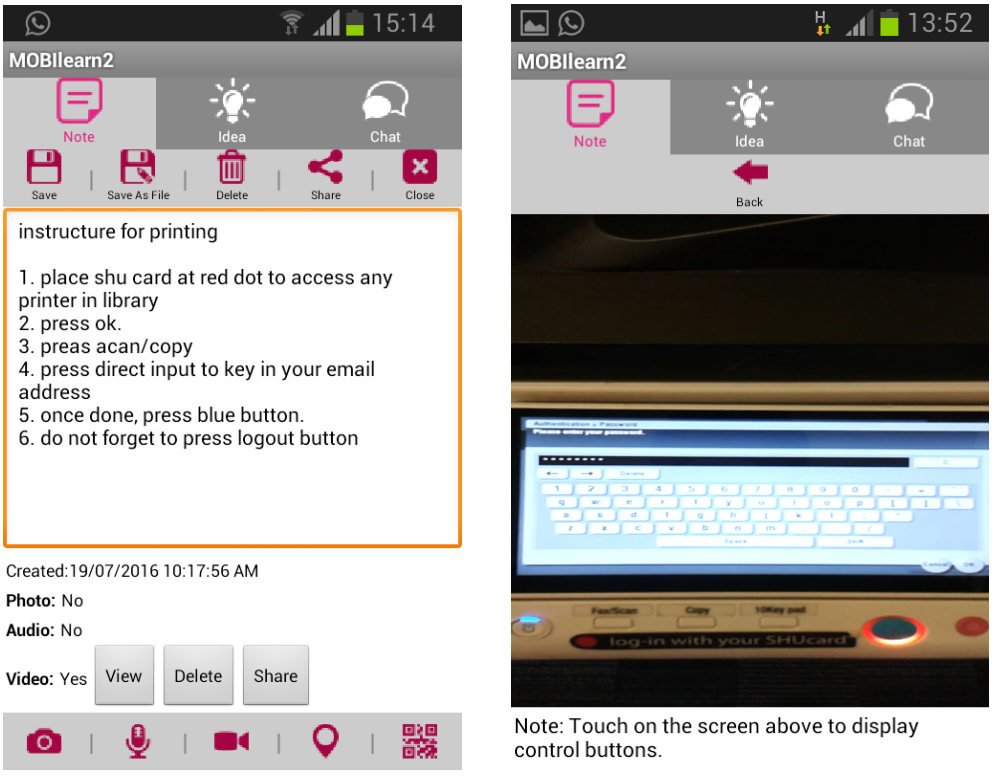
There was no error found when the participants used both of these components. However, there was an issue for audio recording where a participant thought that a button to pause for a break should be provided. This would allow the user to stop recording and continue it again at later time. There was also an issue on device storage for the video recording. One of the participants mentioned that a message of "Space storage running out" popped up on her screen once she saved the video to create the instruction. She also experienced unresponsive condition in the application, which she thought was due to the memory or storage problem.

Regarding the design, all of the participants mentioned that the *Audio* and *Video* components were user friendly, not complicated, and understandable. As observed by

researcher, they conveniently used the components to record data during the exploration. The icons used were adequate and there was no problem with the navigation in both components.

7.6 Task 4 - Create steps or instruction on how to print a document in Adsetts Learning Centre

Based on the results, it was found that most of the participants created steps or instruction by writing it on *Note*. They found that it was easy to use and the component was functional enough to perform the task (ex: save, edit, etc.). However, a few of them added a video as they thought that the audiences could understand the instruction better as shown in **Figure 7.4**.



(a) (b)

Figure 7.4: (a) instruction created by using the *Note* (b) video file presenting the instruction

Despite no error being found on both components, there were some issues similar to the one that has been mentioned in Task 1 (written texts were hidden by virtual keyboard) as shown in **Figure 7.1** and the one that has been mentioned in Task 3 when recording a video.

Both components were perceived as user-friendly by the participants who had performed the task. The icons were suitable for presenting the functions provided and the navigation was effortless. It was evident from field observation that the participants conveniently used the application without any problem. Overall, most of them thought that the design was simple but attractive.

7.7 Usefulness perception and suggestions to improve

Taking note with the MOBIlearn2 application was perceived as very useful by the participants who used it during the exploration. They thought that the application was suitable for conducting research work on the field site as well as journalism as the user could take notes for data and information collected and save it for future retrieval. Nevertheless, they suggested displaying the notes in a list in the main screen, as the number of the notes surely will increase from time to time. So, it could make it easier to retrieve them when the application is started again. The other suggestion was not to make the saved note editable once the user opens it in order to prevent accidental change.

They also thought that the features in the MOBIlearn2 application such as taking a picture and recording a video were very useful when they learnt about a new place and captured information as well as shared their visit or learning experiences. For instance, some of them said that they did not know that HUBs had many interesting places such as café to relax, socialize and become involved with fun activities. Furthermore, they agreed that they

could make their friends aware and learn about the HUBs too by sharing their pictures on social media. However, they emphasized that all the issues found need to be addressed first in order to provide a more reliable application.

One remarkable finding was that the participants found the MOBIlearn2 application really useful because the inclusion of a messenger (*Chat*) to communicate with friends in real time. They thought that the component was really helpful in their collaborative task such as to decide who is going to perform a particular task or to know about a task progress from a member. **Figure 7.5** shows a screen snapshot from a mobile phone of one participant who used this feature.

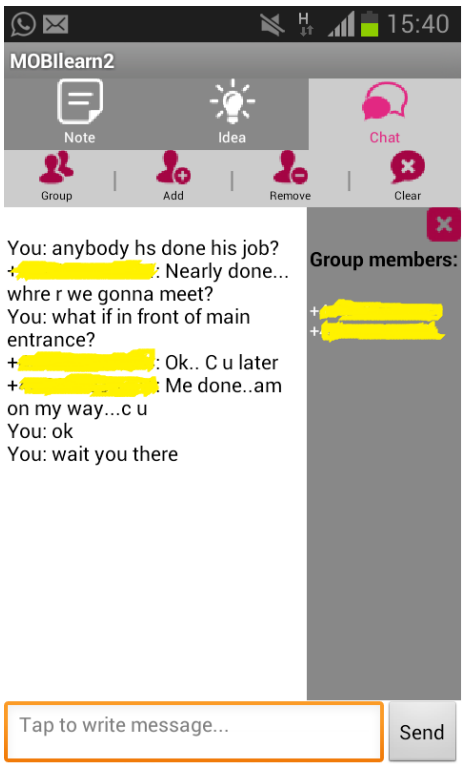


Figure 7.5: A snapshot of screen showing conversations of the participants in a group

One of the participants commented as follow which his group mutually agreed:

> Student B: "*With this feature…I think users can talk or discuss about a task easily…I mean that they can plan or decide together who will do a certain task quickly*"

Despite the positive perception given, they commented that the messenger should display the name of their members instead of their phone numbers. Furthermore, they suggested adding features like a video call, picture attachment and voice message in order to have more effective communication and collaboration. They also suggested that the application have an online-shared folder where they could access, edit and upload a file for their group members at any time.

Overall, they thought that the MOBIlearn2 application was useful because of different kinds of files it could support, the ability to record and save data in audio visual format, effectively for note taking, the many options and integration of tools in single application and a messenger for group communication. Nevertheless, they thought that the application could be improved to have a better support to conduct learning tasks on the move.

Student A: "*It's a very good app…good works…keep it up*"

7.7 Discussion

Based on the findings in this case study, it was found that different participants used different tool to perform a task. It seemed that it depends on their preference and perception when deciding which tool to choose for a particular task. For instance, in the Task 3, some participants used the audio recorder while others took a video to record information. Moreover, it was found that some of the participants only used one component to perform a task and while the others were prefer to use more than one component. For example, in the Task 4 some participants just wrote note to create an instruction, whilst the others added a video file to explain more detail. These findings showed that the MOBIlearn2 application provided personalized use of tools.

After taking all the participant feedback into account, there were several enhancements that had been made to a new version of the MOBIlearn2 application. The enhancements are listed as follow:

1. *Save As File* was removed as it confused all the participants. It was believed that there was no negative effect on the removal as they could save the file on cloud storage like *Dropbox* or *Google Drive* as well as share it as text format via other text-based application such as email or memo.

2. A collection of notes was displayed in a list on the main screen. The separate interface for *Note* was pop up in the screen when a user clicked on any note on the list to read or edit it. This separation enabled the application to maximize the space for the text area in *Note* so that the user could have a better view on the written texts. To add a new note, a button was provided in the main interface. There was also a search function to provide search for a note from list. The change is illustrated in **Figure 7.6**. This design was implemented in *Idea* component as well for the same purposes.

3. A function of speech recognition was provided for *Note* component so that users could have an alternative to take a note without using a virtual keyboard. This enabled the users to record their speech or voice to be converted into texts. With this feature, they were able to see immediately the note texts displayed on the text area.

4. Users could take more than one picture for a note. That means they could take many pictures as they wanted and save them to support a note. The pictures were grouped together so that the user could easily navigate them one by one as shown in **Figure 7.7**. With this new design, the current picture being viewed was displayed on top of a list of other pictures. There was also an add image button displayed next to last picture in the list.

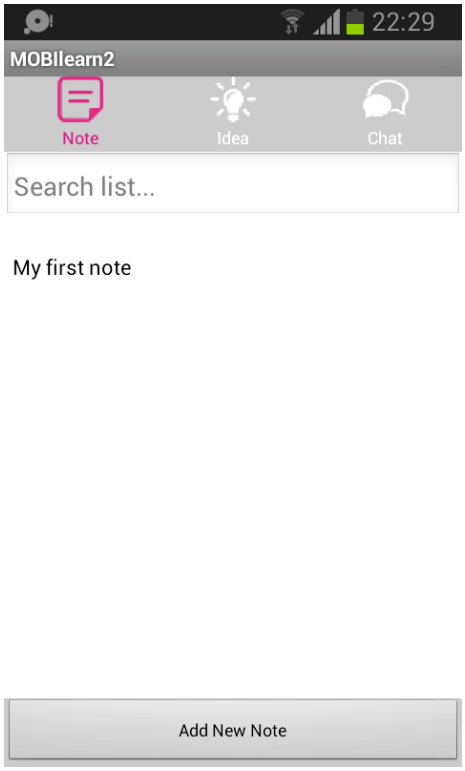


Figure 7.6: Note is displayed in a list with a search function and *Add New Note* button

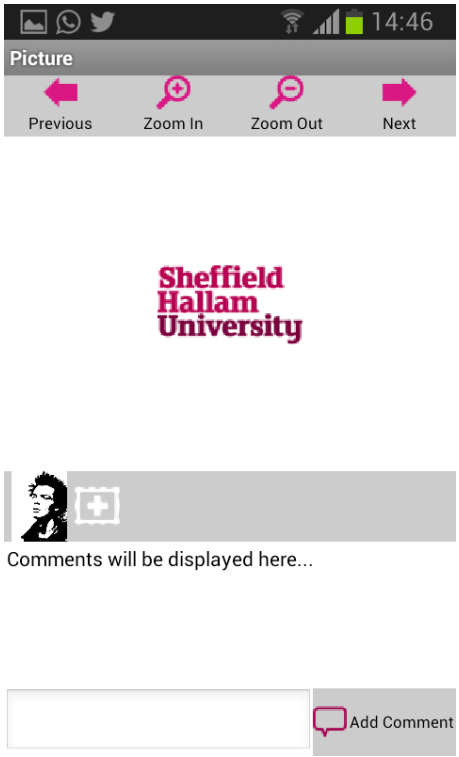


Figure 7.7: A list of pictures could be added and navigated

5. A video call like *Skype* was added in *Chat* to enable richer communication. As suggested by some participants in the study, the new version was provided with a function to do a video call.

6. A function to record and send voice message was provided in *Chat*. This was an alternative to share information with group members.

7. A function to attach a picture for sharing with other group members was provided in *Chat*.

8. A shared folder was created in the application so that users could download, edit, upload and share a file with their friends.

Considering the improvements made for the final version, the study found that there was a need to provide collaboration tool for a mobile learning application particularly the *Chat* component and emphasis on its effective design. The component should be designed to add more functionality in order to enable rich and effective communication and collaboration in real time. Furthermore, the study found that a mobile learning application should include an online-shared folder to provide all users in a team to share a file for collaborative work.

7.8 Conclusions

As a conclusion, it appeared that the MOBIlearn2 application could provide a good support for mobile learners to undertake their learning activities by allowing them to collect data and information instantly and effectively in an authentic environment. With a combination of a variety of tools, the application provided many options for the learners on how to perform a task, as they prefer and in different way. For example, they could use camera or audio recorder to record data and information about a location or building.

Despite the positive feedback from the case study, it was found that the MOBIlearn2 application should be improved to provide richer learning experience for the learners particularly to support their collaborative work. For example, the messenger (*Chat*) could be enhanced with a function to do a video call so that they could communicate in more effective way.

The desire to build up and maintain a record of their learning through the provision of online storage was of particular interest as the scenarios explored in these prototypes were specifically chosen to encourage real-time collaboration learning. It also provided the tie in with the learning provider as such a mechanism could be used to provide the instructions that underpin the learning activity and further information, as required for the task in hand. This way of communication supported the learners to collaborate by allowing them to update their progress, asking questions and make a decision together instantly in order to complete a task.

7.9 Summary

The case study demonstrates that the MOBIlearn2 application provides personalized way to collect data by providing a variety of tools users. Furthermore, they could choose to have different format for their learning resources or files. Therefore, multi-modal learning could be supported by the application so that the learning could be more interesting, engaging and encouraging for learners.

Importantly, the results of the case study indicate positive feedbacks from the participants in all groups despite there are several issues that need to be addressed. In fact, they found the application was very useful to support them in performing learning activity in non-formal environment. Moreover, they found that the design and interface of the

application was user friendly and understandable. Nevertheless, they suggested several improvements in terms of the functionality in effort to provide more reliable tools for mobile learners.

In addition, the findings of the case study show that the participants believed that the messenger system is useful for task collaboration and suggested that the application should be equipped with an ability to access an online-shared folder. They mentioned that the tool and feature are very important to communicate with their members and work on a shared file for their collaborative task.

In the next chapter, the last part of the research project begins whereby a cross-case analysis is conducted and discussed in order to find an overall pattern from the findings in all the previous case studies. It is then followed by a discussion on several use and design guidelines which have emerged from the data and a series of steps to employ a mobile learning application into blended and hybrid learning. There is also a discussion to enhance the current version of the MOBIlearn task model in effort to stay relevant as a design reference in future.

PART THREE

CHAPTER 8

CROSS-CASE ANALYSIS AND DISCUSSION

8.1 Introduction

From March 2015 until September 2016, a qualitative survey was conducted with 3 in-depth interviews for the formal learning case study whilst 3 focus group interview sessions and observation were conducted for the informal and non-formal learning case studies with a total number of 33 student participants mostly at locations in Sheffield Hallam University. Findings for each of the case study have been analysed and discussed separately in the previous chapters of the thesis.

In this chapter, a cross-case analysis is presented and the findings are discussed to highlight particular patterns in order to propose guidelines for appropriate use of mobile learning application and providing it as tools for personal learning activities in mobile environment. The discussion also includes the step-by-step implementation to employ a mobile learning application for blended or hybrid learning. Later, an enhancement on the current MOBIlearn task model is proposed and supported by certain arguments. A summary is provided at the end of the chapter.

8.2 Cross-case Analysis

8.2.1 Case study of formal learning

The first case study primarily aimed at testing the basic components of MOBIlearn2 application and to get feedback for the improvement of the later version.

10 students form different course background voluntarily took part in the study: most of them are female (70%) and post-graduate students (80%).

Findings

The results from the first case study revealed that half (50%) of the participants used more than one tool to collect data. They were taking note and recording audio as well as taking picture and recording video in their learning. The participants also revealed that most of the issues were related to the virtual keyboard usage and audio recording process followed by issues on the saved picture. Despite some errors found in the application, all of the participants (100%) agreed that it was very useful and helpful for their learning activity. This view was supported by their positive comments. They also suggested for adding speech recognition and text-to-speech capabilities into the application as well as a feature to create a mind map. In addition, they did not raise any usability issues in the study.

In this environment, most of the participants were found to have used data collection tools such as taking note and picture to collect data and information. It appeared that it was due to the formal setting where an instructor normally delivers a lecture in a seminar or workshop. In the setting, the students paid attention to the teaching and slides or materials presented by them. It was believed that most of the time in the seminar, only the instructors were giving lectures and it was rare to find a student interrupting the flow since the Q&A session usually took place at the end of the session. Therefore, the students were just using that kind of tools during that time.

8.2.2 Case study of informal learning

The objective of the second case study is to evaluate the design and functionalities of MOBIlearn2 application. Particularly, the study would like to investigate how the application could support informal learning activities and how the application could be improved. 12 students were recruited as participants in this study. They were coming from different courses: design-based post-graduate (33.3%), non-design post-graduate (33.3%) and diverse undergraduate (33.3%).

Findings

The results from the second case study revealed that most of the students used the combination of tools: taking picture (91.7%), taking note (83.3%), and recording video (50%) and followed by recording audio (16.7%) and map (8.3%). Interestingly, although did not use social network applications such as *Twitter*, some of them believed that the tools were useful for the users to share their experiences with their friends. The participants also found some errors mostly related to *Video* component. However, this technical error caused by a bug to the tablet operating system platform was successfully fixed in second evaluation. Some of the comments (37.5%) were related to design improvement and the remaining (62.5%) was related to suggestions for adding new features for the application such as QR code scanner.

In the second evaluation, all of the participants (100%) were satisfied with a simpler design of the application, which was having more attractive icons. As stated by McNeill, Diao and Gosper (2011), the use of digital technologies among students is still conservative resulting in them valuing familiarity and ease of access.

Additionally, the later version was provided with access to social network component tools such as *Facebook* and *Gmail*, QR code scanner and *Sketch* component for drawing requested by them.

Based on observation in the study, it was found that most of the participants used data collection tools such as taking picture and note to collect data and information by interacting with their surroundings. As they walked on a learning place such as museum or gallery, they took a picture or recorded a video using the application spontaneously. The application became a platform for interactivity, information access, rich media presentation and flexible use. This finding was similar with result from a recent study by Rhee and Choi (2015). Moreover, the participants also agreed that social network applications were really useful in order to share their pictures and files with their friends to generate in-depth discussion or talk about their learning experiences.

8.2.3 Case study of non-formal learning

The last case study aimed at evaluating the learner experiences on using the MOBIlearn2 application to support their activities in non-formal environment and finding any opportunity for improvement. There were 11 students from diverse background participated in the study: most of them were female (54.5%) and undergraduates (63.6%).

Findings

The results from this case study revealed that the participants had used different tool for task depending on the nature of the task. Basically, the participants were taking note for simple data collection, taking picture for visual information and recording video or audio for more complex tasks to capture rich information. The participants also mentioned that most of the issues found were related to hardware limitations (small screen and storage). Nevertheless, they found that the design of the application in terms of Graphical User Interface (GUI) elements, navigation and themes was generally user friendly. Essentially, they found that the application was really useful to learn in that learning environment due to the communication capability provided as a messenger (*Chat* component) that could support their collaborative task. In addition to design improvements, they also suggested adding more functionality into the messenger so that it could provide richer communicative and collaborative capability for the learners. Furthermore, there was a requirement for the application to include an online-shared folder to share for group to perform a collaborative task.

In this environment, it was found that a number of participants used the *Chat* component to provide status of their tasks and communicate in real time in addition to the data collection tools during the study. Particularly, they used the tool to support their collaboration activities such as generating a discussion, updating progress of work and making a decision at real time. Another important finding was there was a request to have online-shared folder and it was mutually agreed by all of participants in a group.

8.2.4 Summary of comparison

A summary of the comparison is presented in **Table 8.1** pointing out the extracted themes based on codes found across the case studies.

Table 8.1 A summary of comparison between all the case studies.

Contexts / Codes	**Formal learning**	**Informal learning**	**Non-formal learning**
Usage	- half use > one tool - 1. take note 2. record audio 3. take picture 4. record video - prefer different resource format	- uses a combination of tools - 1. take picture 2. take note 3. record video 4. record audio	- different tool for different kind of task (taking note for simple task, taking picture for visual information and recording audio and video to capture richer information)
Errors/ issues	- most of the issues found were related to virtual keyboard and audio recording process	- most technical errors related to *Video* component	- most related to hardware limitations
Design	- No issue raised	- some issues related to interface and components - 100% satisfied after improvements	- generally user friendly - provide notes in a list
Usefulness	- useful and helpful	- useful and helpful	- useful and helpful
Comments/ Suggestions	- generally positive - to provide more capabilities for data collection (ex: text-to-speech, speech recognition, mind map application) and data backup	- generally positive - to provide more access to social network tools such as *Facebook* in order to share learning experiences - to provide drawing or sketching tool	- generally positive - to provide more functionalities such as video call on messenger system (*Chat*) to support collaborative task - to provide an online shared folder for collaborative work

All case studies results show that most of the participants: (1) used a combination of tools; (2) thought that the application was useful; (3) preferred simple and user friendly interface; and (4) gave positive comments. The findings are in line with the field observation data that show the participants using more than one component in the application as well as they find it easy to use the integrated tools designed in application. However, different errors and suggestions are found as below:

1. issues related to data input and suggestions to have more capabilities for data collection in the formal learning
2. issues related to device operating system platform and suggestions to have more access to social networking tools in the informal learning
3. issues related to device hardware and suggestions to have more functionalities for collaboration in the non-formal learning

8.3 Discussion

Following the cross-case analysis presented in the previous section, this research project proposes guidelines for design and appropriate use of mobile learning application based on the contexts of learning, which are formal, informal and non-formal. For each of the context, this research project also proposes a set of recommendations for developers to design a mobile learning application as tools for personal learning. To provide a better picture of design guidelines to designers and programmers, an ideal version of mobile learning application is proposed and described as a personal tool to support mobile learning activities. These design guidelines only have the implications for the usage pattern of a mobile learning application.

Moreover, a set of general guidelines emerged from the field observations is proposed to support learning in all contexts that are need to be considered by designers to provide rich learning experience for mobile learners. Later, a step by step on how to implement a mobile learning application into a blended or hybrid learning is presented and finally an enhancement on the current MOBIlearn task model is proposed at the end of this chapter.

8.3.1 Appropriate use of mobile learning application

In this section, this research project proposes guidelines for design and appropriate use of mobile learning application for three learning contexts, which are formal, informal and non-formal separately. The guidelines also include a set of recommendations that present the order of priority for features that need to be provided by designers for the learning application. The guidelines are presented as follows:

Formal learning

For formal learning, this research project proposes that a mobile learning application should be designed and used primarily as a data collection tool. In this learning environment, learners usually attending a lecture, seminar or workshop in which they are listening to an instructors' speech or presentation. With the minimal interaction, they are normally writing notes, sketching or taking pictures to collect the data and information for their learning resources. As pointed out by Andrews and Jones (2015), taking a photograph is the most popular for learning activity in a seminar as well as using voice recorder, creating voice memo and making short video.

However, there is also a requirement for being able to share their learning materials with their friends and collaborating in a group to perform an assignment.

Given the reasons mentioned above, this research project recommends *Collection* > *Extra* to design a mobile application as tools for data collection in the formal learning context. Based on the recommendation, the most important features that could not be lacking in the application are the *Collection* features or components in order to perform data collection, and then followed by *Extra* tools. These *Extra* tools could be in the form of social and collaborative tools or a combination of them depending on the requirements of learners.

Learning application designers or developers therefore must first of all provide the *Collection* features such as note taking, camera application, audio and video recorder, speech recognition and drawing capability into their applications that could fulfil the requirements for mobile learners to collect, manage and retrieve data. To provide a better learning application, the designers must provide a variety of ways for the learners to collect data so that it could be suited with the formal learning environment and to avoid any distraction. Once all of the previous features have been embedded, the designers could proceed by adding the social network or collaborative tools into the application if necessary. To support the extra requirements therefore, there should be a link button to access social client applications such as for *Twitter*, *Facebook*, and *Instagram* as well as commercial collaborative applications such as *Skype* and *Dropbox*.

Informal learning

For informal learning, this research project proposes that a mobile learning application should be designed and used primarily as a social application tool. In this learning environment, learners usually visiting a museum, art gallery or cultural institutions in which they are engaging and interacting with the exhibits, displays, presentations or events in the surroundings. To fully engage in the interaction, they are normally taking pictures and videos, sketching and scanning a QR code to collect the data and information and finally share their experiences with friends. Therefore, to support their sharing and meaning making, a mobile learning application should be designed as a social learning tool in which they could communicate, converse, discuss and share learning materials with their friends or community (Pachler, Bachmair & Cook, 2010). However, sometimes there is also a requirement for being able to collaborate in a group to perform a collaborative work.

Given the reasons mentioned above, this research project recommends *Social* > *Collection* > *Collaborative* to develop a mobile application that focus on social learning. Based on the recommendation, the most important features that must be included in the application is *Social* features or components, and then followed by *Collection* and lastly by *Collaborative* tools. Hence, learning application designers or developers must first of all provide the *Social* features such as writing post, activity stream or content feed and then followed by *Collection* features such as camera application, audio and video recorder and QR code scanner into their applications that provide a variety of data collection methods. The presence of *Social* features, together with the *Collection* tools, is a necessary condition to provide effective support for the mobile learners to learn in such environment. However, the designers or developers

also need to make sure that the features are properly working on every device platform, as a very wide range of learners will communicate in a big social network.

Once all of the previous features have been embedded, the designers could proceed by adding the *Collaborative* tools such as messenger and online-shared folder could be provided if needed or there are additional financial or technical resources available.

Non-formal learning

For non-formal learning, this research project proposes that a mobile learning application should be designed and used primarily as a collaborative learning tool. In this learning environment, learners are usually performing a collaborative task or activity together, which is given by their instructors or teachers in a workshop. Most of time, they are given a range of choice on how to perform their task based on their creativity with a minimal guidelines in order achieve a specific learning goals. In the activity, they are normally engaging in a communication, conversion or discussion to find meaning or solution for a particular problem. They are also involved in planning an activity, accessing a shared file as well as making decisions together. Nevertheless, sometimes they share their learning resources and interact in a preferred social network, which they found useful.

Given the reasons mentioned above, this research project recommends *Collaborative* > *Collection* > *Social* to develop a mobile learning application that focus on collaborative tools. According to the recommendation, the most important features that must be included in the application are *Collaborative* features or

components, then followed by *Collection* and lastly by *Social* networking tools. Learning application designers or developers therefore must first of all need to provide the *Collaborative* features such as a messenger, video conferencing or online-shared folder into their learning applications that could support work collaboration. Then, the designers could provide the *Collection* features such as note taking, camera application, audio and video recorder, speech recognition and drawing capability. Nevertheless, the designers or developers have to consider the limitations of learner devices so that they could work properly on the move without any issue.

Once all of the previous features have been embedded, the designers could proceed by providing the *Social* tools to enable the learners to share their knowledge and learning experiences with their friends. Nonetheless, this is depends on the learner requirements as well as the financial and technical resources available.

8.3.2 Ideal version of a mobile learning application

In this section, an ideal version of a mobile learning application that has all of basic features for each of the tools (*Collection*, *Social* and *Collaborative*) is presented to provide design guidelines for designers and developers. The tools however could be improved to have more functionality depends on the requirements and available mobile device technology.

a. *Collection*

As observed in the first case study, most of the participants used the MOBIlearn2 application to collect data. Therefore, designers and programmers are

recommended to include *Collection* tools into their application. The *Collection* tools basically provide functions to write, save, edit and manage notes for users in many ways as shown in **Figure 8.1**. In addition to text, users could take notes by enabling the speech recognition function so that they do not have to type and use small keyboard. Instead, they just speak and say the words for the application to write it down on the screen. Moreover, the user could create a mind map and do sketching to brainstorm, structure their idea and capture information depends on their preference.

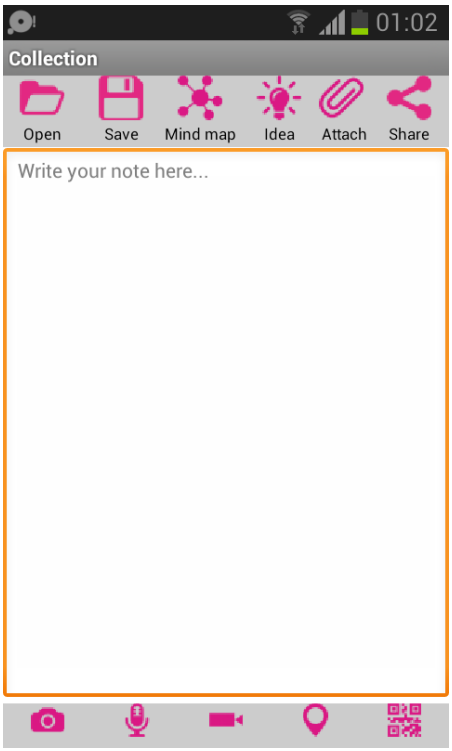


Figure 8.1: Main interface of *Collection* tools

Additionally, the users could attach any files or images saved in their devices to the note and share it with their friends or community by using any commercial application such as *Gmail*, *Facebook* or *Dropbox*. With the tools also, users could use location-based technology such as GPS to access location data. To deal with interior space such as in the university, the users could use QR code scanner to access data that could be displayed on their device screen.

b. *Social*

As observed in the second case study, most of the participants used the MOBIlearn2 application as social tool. Therefore, designers and programmers are recommended to include *Social* tools into their application. Ideal *Social* tools represent a combination of commercial social network client applications to support social, conversational and constructive learning for students. With this combination, the students could view, access and interact with their social community in more efficient way. As illustrated in **Figure 8.2**, several main social network client applications such as *Twitter*, *Facebook, Instagram*, *MySpace* and *Snapchat* could be accessed in one application.

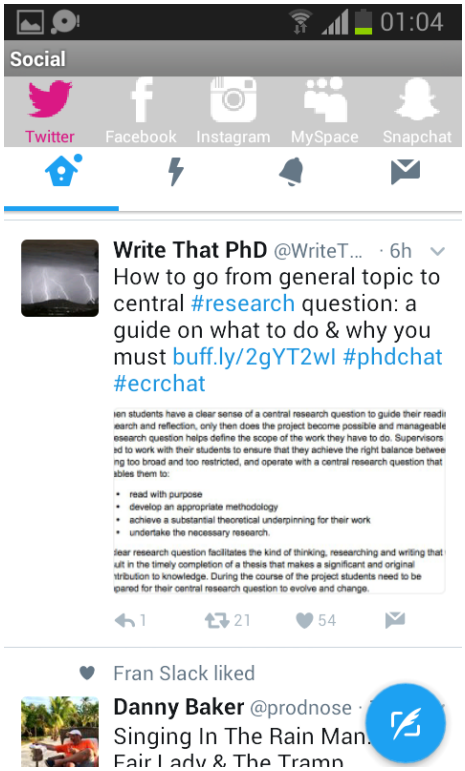


Figure 8.2: An integration of social tools in a learning application

The users are able to interact with their learning community by viewing the content feed or post on their account timeline. They could select which post or feed

they want to repost, make and reply comments, click on *Like* button, chat privately, copy link or share by click on one of the topics. These kinds of tools normally appropriate for informal learning in order to provide extra discussion and engagement beyond classroom.

c. *Collaboration*

As observed in the last case study, most of the participants used the MOBIlearn2 application to collaborate with their members to perform a task in a group. Therefore, designers and programmers are recommended to include *Collaboration* tools into their application. The *Collaboration* tools are very important to be provided for learners especially to support them to learn in a non-formal environment. **Figure 8.3** illustrates an ideal collaboration tools where the learners could communicate, set up a study group, add or remove a group member as well as access an online-shared folder.

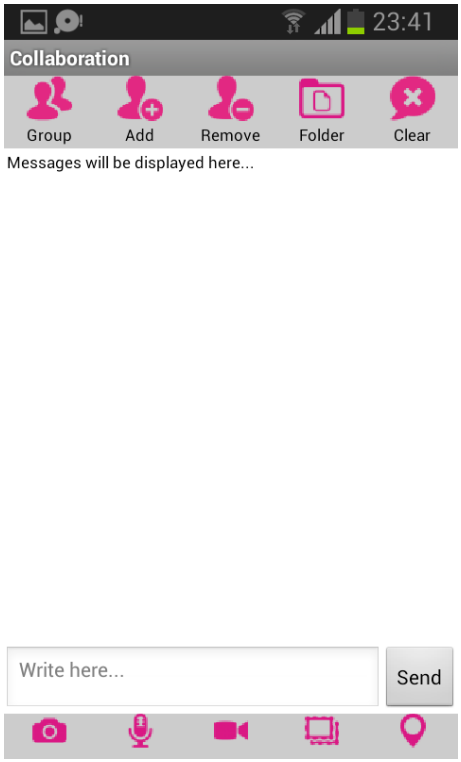


Figure 8.3: *Collaboration* tools to support collaborative learning

Using this tool, the learners could have online discussion or meeting by texting, audio notes or video call. They also could access device gallery to attach a file to share with their members. In addition, the special feature of the tools is ability to access custom online-shared folder and commercial cloud storage such as *Dropbox*, *iCloud* or *Google Drive* to collaborate in a task. The group members could download, view, edit and upload a file for other members to work on it.

8.3.3 General guidelines for all contexts

In addition, this research project finds that the following features are very essential to be considered by designers and educators in order to provide rich learning experiences for mobile learners for all contexts:

1. Seamless across applications

Data from second evaluation in informal case study shows that all of participants (100%) were satisfied with the new design and features of the MOBIlearn2 application. Likewise, most of participants in non-formal case study provided the same response to the application design and features. This indicates that in order to connect learning experience across all contexts, a seamless transition and integration across applications are very important. This is because of the mobile learning application used by the learners need to be linked and combined with other commercial application to provide more advanced functionality in order to provide effective tools and share learning materials and resources. By this seamless characteristic, learners could use many applications developed by different providers that are built for different platforms without any error and issue. The social and collaborative experiences will be improved as well.

2. Seamless across devices

It is evident in the formal and non-formal case study that the participants used a wide range of mobile devices with a wide variety of operating system platform versions. The devices consisted of several mobile phones and a tablet from different manufacturers such as Sony, Samsung, Motorola and even DingDing with different versions of Android. As the participants preferred to share information, learning materials and experiences using the MOBIlearn2 application with their friends in the case studies, the designers have to make sure that it can

be done seamlessly in learners' mobile learning applications that are installed on different kinds of devices. This seamless feature enables the learners to receive the same quality of information, resources and services in a different types of mobile devices regardless the hardware specification such as memory and resolution. As each learner uses different kind of devices, this feature is important for a successful personal, social and collaborative learning.

3. Seamless across environment

Data from field observation in all case studies shows that the participants were moving in and out of physical and digital learning environment either they were realizing it or not. For example, they used digital devices and applications to collect data and information by interacting with materials or objects found in a physical area of where they are located in Millennium Gallery in the informal case study. In the last case study, they were also moving in and out of formal, informal and non-formal learning contexts where they collected, stored and retrieved data to conduct a learning task or achieve their learning goals during exploration. This data indicates that mobile learning happens across personal and social settings or environments on daily basis depending on the requirements and preferences of the mobile learners.

4. Self-directed

Data from the formal case study shows that half (50%) of the participants used more than one tool to collect data, whilst most of the participants in the informal case study used a combination of *Picture* (91.7%), *Note* (83.3%) and *Video* (50%) tools in the MOBIlearn2 application. This data reveals that mobile learners select their own tools to collect data and identify their own materials for learning. As suggested by participants from Group A and C in the non-formal case study, mobile learners also should be provided with the capability to share their learning resources using a range of tools such as email and social networks. They want to have freedom to choose what, when, how and where they want to learn with or without the help of teachers or instructors. The mobile learning application therefore needs to provide these capabilities in effort to support effective self-directed learning for them in all contexts.

5. Start small and build from that

As demonstrated in this research project, the MOBIlearn2 application has been designed throughout an iterative process. The application has been refined based on feedback of the participants in each case study for a particular context. This practice suggests that a mobile learning application should be built from small but contains basic tools to support and connect learning across contexts. Starting from that, more additional variety of tools could be provided depends on the students' requirements. This approach is useful for small-scale application that

has limited time and cost. For example, the designers could start with *Collection* features and proceed with either social or collaborative learning tools to develop a mobile learning application for formal learning contexts.

6. Support multiple pedagogies

The data from all case studies shows that the participants were actively involved in a learning task, either individually or in a group. As observed in the informal case study, they preferred to share their learning materials with their friends and suggested to have access for social applications such as *Twitter* from the MOBIlearn2 application. They also worked collaboratively to conduct a task during the exploration in the non-formal case study. This data confirms that students are active learners rather than spectators. They construct their own knowledge and understanding by identifying learning resources and solving a problem in authentic environment. Furthermore, they create their own social group or community, interact with each other and work collaboratively to achieve specific learning goals. Hence, the designers and educators should make sure that the mobile learning application they provide must support this multiple pedagogies in order to have maximum impact for their learning.

8.3.4 Steps suggested for educators to implement a mobile learning application into blended or hybrid learning

The findings of this research study conform to some of previous researches, which indicate that mobile learning is not for replacing the traditional classroom learning, but just for complementary. Therefore, this study suggests for educational institutions to have a blended or hybrid learning to utilize a mobile learning application such as MOBIlearn2 with the conventional classroom learning methods in effort to increase the impact and quality of learning. To implement effective blended or hybrid learning however, mobile devices and applications should support it. As reported by Farley et al. (2015), 87% of students were in favour of using their mobile devices to support their learning either in class or at distance. They would appreciate more interactive learning activities in class or via mobile devices that would enable them to experience real world problems related to their studies.

For that purpose, it is believed that the institutions could follow a series of steps as implemented in the previous generations to embed technology into mainstream education as pointed out by Bachmair and Pachler (2015) with reference to earlier work by Cuban (2001) and Lomicka (2003). The steps to introduce a mobile learning application into blended and hybrid learning are described as follow:

1. Entry

It is found that participants of the case studies in this research project used latest mobile device technology and application. For instance, there was a participant who used a Samsung Galaxy Note 10 and another participant who

used a Samsung Galaxy Tab 2 tablet in the first case study that host latest Android operating system and application. Therefore, instructors need to get familiarized with the latest mobile learning application and devices as the new mobile technology innovation is becoming more sophisticated. Importantly, they need to know how to use the advanced learning application and operate the device so that it could be appropriately utilized for educational learning contexts. To achieve this condition, technical training could be provided for all instructors in this stage.

2. Adoption

As found in this research project, most of the participants in the case studies brought their own mobile phones and installed the MOBIlearn2 application on those devices. This indicates that the participants were really interested to use their own mobile devices for the learning activities. Hence, the instructors should provide some demonstration and explanations on how to use a mobile learning application in blended or hybrid learning approaches. This is to ensure the learners to understand how to use the learning application properly so that it could effectively support their learning activities, instead of distracting them from concentrating on the lesson especially in formal and non-formal contexts.

3. Adaptation

As demonstrated in the formal and non-formal case study, the participants used the MOBIlearn2 application to collect, store and retrieve their learning resources across contexts. This data reveals that a mobile learning application is a good tool to implement blended learning in educational institutions. In blended or hybrid learning, the traditional learning approaches to instruction are maintained but some class time is allowed for the learners to use mobile learning application for homework and daily learning activity. The adaptation of the blended or hybrid strategy is important in order to see how they could bridge the learning across different contexts with the support of the application.

4. Appropriation

This research project finds that the appropriation use of a mobile learning application is a very important factor to ensure rich learning experience for learners. This data reveals that designing an ideal mobile learning application that suits every context needs an iterative approach. The instructors therefore need to regularly integrate the mobile learning application into the curriculum. They have to monitor how the learners use the application, customize the application according to the learning activities and learner needs, detect any issues that need to be addressed and maintain the learning effectiveness with the support of the application.

5. Invention

It was found that the requirement of the participants increases after each case study. For example, some participants requested to have a function to annotate a picture after the first case study, whilst other participants requested to have a sketching tool after the first evaluation of MOBIlearn2 application in the second case study. Given that reason, the instructors have to collaborate with mobile application designers to help them to keep inventing new features in order to meet new demands of learners. They also need to find new ways to connect learners with learning tasks and use project-based and interdisciplinary approaches to instruction. It might be an improvement in terms of method, practice or process to achieve better learning output or quality in education.

By implementing the previous steps, it is believed that educational institutions can make sure that pedagogy is driving the use of mobile application technology instead of the opposite. To be effective however, institutions are going to have to rely on students' own devices, as they will not be able to afford to provide special equipment for every student (and the students will not want to carry an additional handset when they have one already). This means that the application must provide all the functionality needed for all the different types of learning. Having everything in one place with a common interface makes it much easier to use.

8.3.5 Enhancement on the MOBIlearn task model

In addition to guidelines for designing a mobile learning application and a series of implementation steps for blended or hybrid learning, this research project proposes an enhancement on the MOBIlearn task model. The enhancement consists of a change and two new elements that are to be included in the task model in effort to provide more details and deeper understanding.

The change to be made is replacing the factor of *Communication* with *Collaboration*, whilst the new elements in the model are *Changed Subject* and factor of *Continuity*. The proposed enhancement is illustrated in **Figure 8.4** and highlighted in the task model. The arguments behind this enhancement are presented in the following subsections.

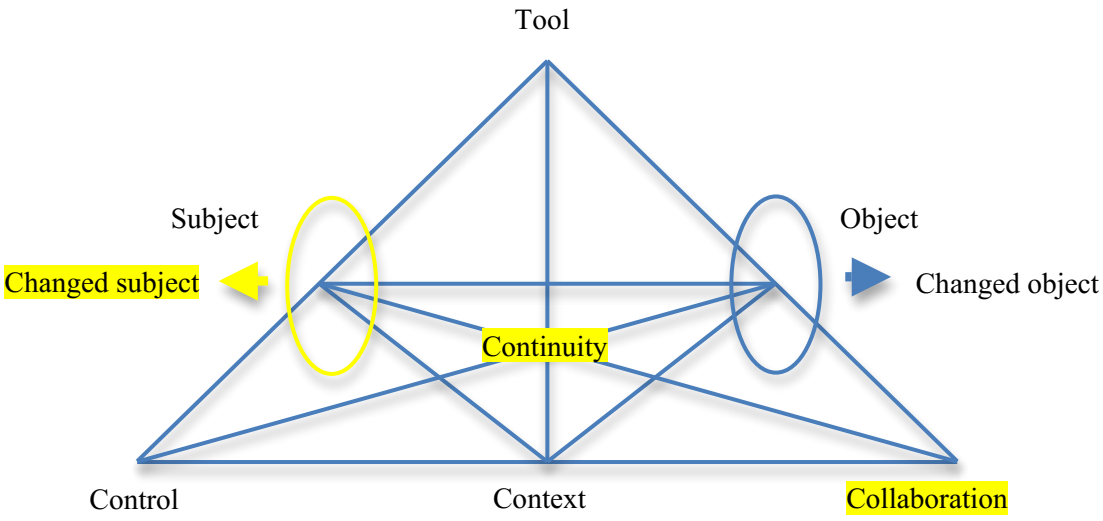


Figure 8.4: The enhanced MOBIlearn task model

a. *Collaboration* factor

The arguments underpin this proposed change is that it is believed that the term collaboration is more accurate instead of the communication in order for the factor to present for all the relevant contexts including educational, technological and social.

In educational context, the word collaboration refers to the group learning practices where some if not all the individuals are contributing and working together either online or in a physical environment. The term collaboration also can represent other pedagogical theories such as active, constructivist, conversational, cooperation, connectivity, interactive and social learning. In collaborative environment, learners interact and engage in a common task to search for a solution and achieve specific learning objectives. They learn something together by negotiating the meaning, sharing the experiences and reflecting on each other.

Technological perspective, the collaboration is supported by information system including software and hardware. The software is the application designed to help learners involved in a common task to achieve their learning goals. It provides a way of sharing documents and rich media to enable more effective group collaboration. The hardware includes the computers, mobile and network technologies that support learners to collaborate across locations and times.

In social context, collaboration is performed in community of practice or organizations where collective activities are carried out to achieve specific learning goals. This study argues that collaboration is not only communication

or discussion, but it goes more than that to include the opportunity for different groups of people to construct a new dimension of ideas or perceptions.

b. Changed subject

Involving in a learning activity enables the growth of the learner's knowledge and skills. The activity has modified their current knowledge schemes to integrate new information and experience and results in a new or deeper knowledge and understanding. The learners build their knowledge and construct their understanding throughout the process of learning in various contexts when they interact with the object such as information and learning resources mediated by tool. Given this interaction, this study argues that not only the object will change, the learners as the subject will change as well.

However, the impact of learning depends on the pedagogical practices or the quality of the learning activities conducted for them. The study acknowledges that not every learner could learn thing in the same way and has the same impact from a learning process. Therefore, it is up to the teacher or instructor to make sure that every learner is participating so that the impact could be maximized.

c. *Continuity* factor

In order for the MOBIlearn task model to remain relevant to be as a reference for future, a new factor, which is called *Continuity*, should be placed

in the centre of the model. This research study argues that the *Continuity* factor is very important and it must be considered for a few reasons as follow:

1. The mobile technology innovations are always happening as mobile device is constantly developed and improved to accommodate consumer needs.

2. Learning activities are constantly designed and evolved in order to adapt with pedagogical requirements for mobile learners.

3. The format of learning materials is always refined to adapt with new version of mobile device technology platform.

4. The control is always changing between learner, teacher and technology.

5. The learning context is always changing from personal and social or from formal, informal and non-formal learning.

6. The collaboration is happen for a period of time for a group of learners in order to achieve particular learning goals.

From the technological space of the task model, *Continuity* represents the continuous improvement and innovation in mobile technologies including the hardware and software to support the mobile learning applications. The ability to maintain innovation over time is very important to have sustainable good educational practices in order to become embedded into mainstream practice (Bachmair & Pachler, 2015). Moreover, *Continuity* can represent the availability of mobile services that is always on and the ubiquitous or pervasive access and dissemination of materials and knowledge.

In semiotic space, *Continuity* takes place at all levels. For example, the learning activity is always changing and developing to accommodate and adapt with the curriculum and learners requirements. This is very important to be considered by the instructors if they want to make sure that activities are pedagogically sound. The *Continuity* also happens at cognitive level when the mobile learners are continuously learning new things throughout their life. Moreover, the *Continuity* also can represent the seamless learning to emphasize the bridging of the learning effort across a variety of settings to have a better learning experiences and impacts.

8.4 Summary

As a summary, the findings across all the case studies have revealed a pattern of the MOBIlearn2 application usage, issues, design and useful perceptions as well as the participant preferences for functionality in particular learning settings. The findings show that the learners used a combination of tools, satisfied with the design of the application and gave positive comments. Most importantly, this research project suggests guidelines for appropriate use of mobile learning application based on formal, informal and non-formal learning contexts. This research project also recommends an ideal mobile learning application that contains *Collection*, *Social* and *Collaboration* tools for personal learning activities across contexts.

In addition, the research study finds several general features based on the observations made across all the case studies which need to be considered as guidelines by designers to provide rich learning experience for all contexts: (1) seamless across applications; (2) seamless across devices; (3) seamless across environment; (4) self-directed; (5) start small

and build from that; and (6) support multiple pedagogies. With this in mind, the mobile learning application is expected to provide better support for the learners to learn effectively and to bridge their learning across contexts.

It appears that, different mixes of students did not affect much of the study results. Despite some of design-based students were concerned about the interface of the MOBIlearn2 application, most of them were satisfied with the design and functionality provided. This indicates that most of the students are already getting familiar with standard components used in the application and Android platform installed in their devices.

Furthermore, this research project recommends instructors or educators to introduce a mobile learning application into their teaching by implementing several steps similar to the one for implementing computer technology into education. The steps include the stages of entry, adoption, adaptation, appropriation and invention. At the end of this clear and creative procedure, it is believed that the instructors are able to utilize the application as a supportive tool in blended or hybrid approach to achieve learning objectives.

Finally, this research project suggests an enhancement for the MOBIlearn task model based on lesson learned across all the case studies. The enhancement is consists of a replacement for *Communication* by *Collaboration* factor and adding two new elements, which are *Changed subject* and *Continuity* factor. The purpose of this enhancement is to provide a better understanding for mobile learning designers and educators and to keep the task model relevant for mobile learning in the current technology age.

CHAPTER 9

CONCLUSION

9.1 Introduction

Designing a mobile learning application is a very challenging process due to the lack of guidelines for appropriate use and unavailability of tools for personal learning activities (Sharples, 2013). Fortunately, there are several mobile learning models that provide basis for that purpose including MOBIlearn task model. The task model is underpinned by many popular theories of pedagogy. It provides a comprehensive framework to understand the important elements for implementing a successful mobile learning environment. However, the task model should be investigated to capture pedagogical requirements and test a mobile learning application against them in an effort to bring the theory into practice of education.

This research project attempted to fill a gap in the existing research as mentioned above. Specifically, the research project investigated the MOBIlearn task model to synthesize a set of pedagogical requirements for mobile learning and designed an initial mobile learning application prototype based on the requirements. To validate the requirements, the research project evaluated learner experiences of using the prototype in three separated case studies that represent three different learning contexts and ended up with a cross-case analysis and discussion of the pattern emerged from the data.

The aim of this research project was to design a pedagogically sound mobile learning application based on the MOBIlearn task model to provide guidelines for appropriate use and to provide tools for personal mobile learning activities across formal, informal and non-formal contexts. Specifically, objectives of the research project were to determine pedagogical requirements for mobile learning from the MOBIlearn task model; evaluate

learners experiences of using a mobile learning application designed based on the MOBIlearn task model to support their learning activities; provide guidelines for appropriate use of mobile learning application and tools for personal mobile learning activities across contexts; and confirm the MOBIlearn task model as a design reference for designing a pedagogically sound mobile learning application for educational purpose.

9.2 Setting the scene

This research project was designed to address the following research questions:

1. What are the learning activities performed and resources accessed by learners in mobile environment?
2. How control, context and communication could support pedagogical needs in mobile environment?
3. How do learners experience learning with the support of a mobile learning application that is designed based on the pedagogical requirements?
4. How could a mobile learning application be designed for appropriate use and as tools for personal learning activities across contexts?

The first and second questions were addressed with the findings from a systematic review on the MOBIlearn task model (Khan et al., 2003; Kitchenham, 2004); the third and fourth questions were addressed with qualitative data collected and patterns emerged from the three case studies (Yin, 2009).

The research project was divided into three parts. In the first part, the systematic review on the MOBIlearn task model was conducted by using online database provided by Sheffield Hallam University. The findings of the systematic review were used to design an

initial mobile learning application prototype called MOBIlearn2. The research project then proceeded into the second part by setting up a case study of: (1) mobile learning in a seminar or workshop; (2) mobile learning in Metalwork Collection of Millennium Gallery; and (3) Sheffield Hallam University exploration. For the final part of the project, a cross-case analysis was conducted to discuss the emerged patterns of data found in all the case studies to answer research questions.

9.3 Research methods

The research project conducted a systematic review on the MOBIlearn task model contributing factors in an effort to answer the first research question stated in the previous section. For that purpose, a total of forty-five key research articles, mostly from conferences and journals that were published from 2001 until 2014 have been consulted. As inclusion criteria, the review study selected primary studies that define one or some of the task model factors, which could be accessed in university's online database. The review also excluded all the works that did not discuss any of them. The findings were grouped for similar concepts according to the task model factors to answer research questions and to design a mobile learning application prototype (Glazer & Strauss, 1967).

In addition, the research project utilized a multiple case study methodology, incorporating qualitative data collection and analysis in an effort to answer the third and fourth research questions. A total number of thirty-three students were recruited using purposive and snowball sampling to take part in the case studies. In case study of mobile learning in a seminar or workshop, qualitative data were collected using qualitative survey from student participants and some of them were selected for interview in order to get deeper understanding and insight of the data. In case studies of mobile learning in Metalwork

Collection of Millennium Gallery and Sheffield Hallam University exploration, qualitative data were collected by using focus group interviews (Krueger & Casey, 2008). To enhance the information gathered in the interviews, notes were taken during field observation in both of the case studies. All the data gathered was analysed using thematic analysis to find emerging patterns in each and cross case (Marshall & Rossman, 1999; Braun & Clarke, 2006).

The use of these various methods and sources of data provided the ability to investigate in-depth information and to make appropriate meaning of the data. This research project also used multiple case study approach where the findings could be replicated and validated (Leonard-Barton, 1990). Additionally, multiple methods, data sources and case studies provided the opportunity to triangulate findings (Merriam, 2009).

9.4 Experimental design

For the case study of mobile learning in a seminar or workshop, there were ten student participants studying at different levels (undergraduates, postgraduates, research degree) in Sheffield Hallam University. They were enrolled from a range of diverse courses and took part in the study voluntarily. They used the MOBIlearn2 prototype that was installed on their own mobile devices to learn in a seminar or workshop of their choice. Data were collected through qualitative survey and semi-structured interviews of three selected participants. The data and feedback gathered were used to improve the prototype and refine the interview questions.

For the case study of mobile learning in Metalwork Collection of Millennium Gallery, there were twelve student participants joining the study voluntarily. They were studying at

Sheffield Hallam University in a diverse range of undergraduate and postgraduate degree courses. They were grouped into three groups of four according to their background courses. The study took place in Metalwork Collection of Millennium Gallery in Sheffield where they were asked to find one exhibit that they think attractive to share with their friends. For that purpose, they were given the MOBIlearn2 prototype to collect and store the data in order to present it to their group members after the visit. Data were collected by using focus group interviews and field observation methods. All the data were analysed using thematic analysis technique to find the meaning and insights.

For the case study of Sheffield Hallam University exploration, there were eleven student participants joining the study voluntarily. They were new students enrolling a diverse range of undergraduate and postgraduate degree courses and grouped into three groups according to their intakes. They were provided with the latest version of MOBIlearn2 application prototype. They were also free to either use their own or borrow researcher's mobile devices for the exploration. The study took place in Sheffield Hallam University where they have to explore some locations in order to complete a few given tasks using the prototype. Data were collected by using focus group interviews and field observation methods. All the data analysed using the thematic analysis to find the meaning.

9.5 Discussion of results

Answering research question 1

Mobile learners are continually 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.

Answering research question 2

Mobile 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.

Answering research question 3

Generally, the learners had positive learning experiences, as all of them perceived that the MOBIlearn2 application was very useful and helpful for supporting their learning activities in different mobile learning settings. Their learning experiences were enhanced with the ability to efficiently collect data and information in a variety of ways as well as to manage and store the resources in many file formats for their future revision and reflection. Despite there were some technical and hardware issues, the learners found that learning with the

support of the application was engaging and interactive by allowing them to access social networking tools and work collaboratively with their team members.

Furthermore, the learners found that the design of the MOBIlearn2 application is user friendly and understandable. Nevertheless, they suggested some functionality improvements for future version in order to provide a better support for social and collaborative learning.

Answering research question 4

A mobile learning application could be designed for appropriate use by following guidelines based on learning contexts that it would be used, which are formal, informal and non-formal. In formal context, the application is suitable for collecting data and information as most of the time the learners are attending a lecture, seminar and workshop. On the other hand, in informal context, the application is suitable for sharing and having conversation about learning topics or visit experiences in order to make meaning and have in-depth discussion with their teachers or community. In non-formal setting, the application is suitable for providing support to the learners to perform a collaborative task in a group.

With the learning context guidelines in mind, designers could provide a mobile learning application as tools for personal learning by following the guidelines proposed in this research study. Given that purpose, the designers should consider the followings specifically when designing and developing a mobile learning application:

1. The designers should follow *Collection* > *Extra* recommendation in order to provide efficient data and information collection tools for formal learning context. The extra features could be included based on requirements or available resources.

2. The designers should follow *Social* > *Collection* > *Collaborative* recommendation in effort to provide rich learning experiences for learners in informal learning context. Social network tools are compulsory to have in order to support their social learning and engagement in their community.

3. The designers should follow *Collaborative* > *Collection* > *Social* recommendation to provide support for collaboration activities among the learners in non-formal learning. The application should be a platform for the learners to interact, discuss, engage, make decision, share resources and perform a collaborative task in a group.

Moreover, the designers need to ensure the following features if they want to provide more ideal mobile learning application for the learners across learning contexts: (1) seamless across applications; (2) seamless across devices; (3) seamless across environment; (4) self-directed; (5) start small and build from that; and (6) support multiple pedagogies.

9.6 How they fit into a bigger picture

This research project provides deeper and better understanding on the MOBIlearn task model in order to implement mobile learning in educational institutions. Understanding the pedagogical requirements emerged from the model is very important in an effort to provide rich learning experience for mobile learners across contexts. Despite the fact that the mobile learner requirements might be growing in number following the advance of technology, this project could form a basis for requirement analysis and design work.

Importantly, this research project provides insight into how to apply an educational technology: mobile learning application to support learning activities for higher educational

students. Creating technology is not enough without understanding how it could be used and what kinds of barriers to use that may prevent it from being used effectively. The guidelines emerged from this research project could be followed to develop and employ a mobile learning application in higher educational institutions. This research study's insight could be applied to other situations, especially those with the similar learning contexts.

Equally important, the findings of this research project could be generalized in the form of providing blended or hybrid learning practice at educational institutions. Other institutions or instructors would find values in designing learning activities with the support of a mobile learning application to provide interesting and engaging academic courses to their students. For example, a standard forestry course could be made more interactive and collaborative by providing students with a mobile learning application similar to ideal version of MOBIlearn2 to support their data collection, social learning and collaboration activities. This learning approach potentially would provide more opportunity for them to actively engage in the subject knowledge construction.

Beyond looking at system decisions, educational policy makers are also significant for implementing mobile learning technology. They should revisit existing policies, particularly at the local level, that may be overly restricted in regard to the use of mobile technology at school and university (Mehdipour, Y. & Zerehkafi, 2013). Moreover, they are able to realize the implementation steps as proposed from this research project to adopt mobile learning application into mainstream education. To be successful, support for teachers or instructors should be provided as well.

9.7 Research contributions

One of the key contributions made by this research project is the extraction of pedagogical requirements for mobile learning based on the MOBIlearn task model. The project has demonstrated and discussed how the requirements are synthesized by reviewing systematically the factors on the task model in order to develop an initial design of a mobile learning application. The review provides a deeper understanding and insights by discovering common grounds and similarities from a number of previous research publications.

This research project is not just another implementation of a mobile learning application. It is significant in that it expands research into how mobile learning applications are actually used by students to support their learning activities in different learning contexts. As this research project combines systematic review and case study methodology, it can be seen as a novel step in understanding the pedagogical requirements and issues in the use of mobile learning applications. Despite the importance of a well-designed user interface is not a surprising result, there are importance of including access to a number of social media options and providing a couple of collaborative technologies in the mobile learning application.

This research project confirms the MOBIlearn task model as a design reference for designers to design a pedagogically sound mobile learning application and for educators to design formal, informal and non-formal learning activities. The pedagogical requirements synthesised from the task model are appropriate and matched with the needs of mobile learners. The requirements have been embedded in a mobile learning application and validated by the participants to support their learning activities in the case studies. Furthermore, the specific and general guidelines produced in the study might contribute to improve the current practices of design process in mobile learning application development.

The experiences gained in this research project has led the researchers to propose an enhancement for the MOBIlearn task model in order to provide better understanding of the model and to ensure the model to stay relevant in the future. The enhancements are crucial for sustaining the innovative education provided by mobile learning (Bachmair & Pachler, 2015). The key is to apply and implement the task model into the design practices while deploying the underlying good pedagogical theories to achieve learning goals.

9.8 Limitations

Although the research project has achieved its aim and objectives, there were some unavoidable limitations. Firstly, as the purposive and snowball sampling used in the methodology of the project, the findings or results interpretation might show personal bias of researcher. However, the researcher had shared and published most of the findings of the case studies in journal and conference to get feedback from experts in effort to reduce the bias. Moreover, the research project was conducted with a small size of population for each case study due to the time constraint. For the researcher to conduct three case studies in one year was a quite challenging task. It was still difficult even though the researcher had tried to recruit participants through email letter of invitation. To overcome the problem, the project used snowball sampling where the participants themselves recruit future research subjects. Therefore, it was difficult to generalize the results for larger groups.

Secondly, the order of the case studies conducted in the research project might produce different results compared to the one that might be produced by implementing all the case studies at a time. In the project, the case study of each learning context was addressed one by one starting from formal learning and ending with non-formal learning. There were some reasons for the researcher to choose that method. First, the researcher was not really an

experienced researcher. Hence, after having discussion with the supervisory team, it was recommended to the researcher to conduct the first case study as a pilot study to learn on how to collect and analyze data. With this way, the researcher could have an experience first in order to prepare for bigger case study. Second, because of the cost limit, the research project was conducted with only three mobile devices that were available for the participants to use in the case studies. The devices were two Samsung mobile phones and a Samsung tab, which were installed with Android platform. Hence, it was quite difficult to conduct a big group unless some of them voluntarily used their own devices.

9.9 Future Works

While this research project has demonstrated a design of a mobile learning application that was generated based on requirements extracted from MOBIlearn task model, many opportunities for improving and extending the scope of this project remain. This section presents some of these directions:

1. Sampling process

   As this research project implemented judgmental or purposive sampling and used small sample size, its results were difficult to be generalized for a larger group. Therefore, the future project could improve the sampling process by having bigger sample size, which is more representative for population.

2. Conduct all case studies at a time and compare the results

   This research project conducted one case study at a time. The results and feedback from participants in the first case study were analyzed in order to improve the application prototype for the second case study and so on. However, if all the case

studies were conducted at the same time by using the same initial version of the application, the results might be different. Hence, future research project could undertake this research and compare its results with the results from this project.

3. Learning effectiveness

A fascinating future research project is to adopt an ideal mobile learning application designed based on this research project and evaluate the learning effectiveness for a larger number of students in higher education. The future research could select one topic of learning syllabus, design specific learning activity and provide the application for the students to do specific tasks in order to achieve learning goal. At the end of the study, the learning impact could be measured by comparing the data from pre and post activity.

9.10 Conclusion

In conclusion, this research project is successful because it helps: (1) designers to determine the pedagogical requirements for mobile learning; (2) educators to understand the factors of control, context and collaboration in order to design learning activities; (3) provide researchers with important findings based on the feedback on how the learners experience the learning supported by an application designed based on the MOBIlearn task model; (4) designers with specific guidelines to design a pedagogically sound mobile learning application for each learning context; (5) designers with general guidelines to design a pedagogically sound mobile learning application for all contexts; (6) educators to employ blended or hybrid learning with a series of implementation steps; and (7) to contribute to the enhancement of the task model for designers, educators and researchers.

Importantly, this research project has contributed to the field of mobile learning by providing guidelines and recommendations for appropriate use of mobile learning application based on learning contexts and tools for personal mobile learning activities across contexts. Furthermore, this project has confirmed the MOBIlearn task model as a reference for the design of a pedagogically sound mobile learning application.

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APPENDICES

Appendix A

INTERVIEW CONSENT FORM

Research title: Framing pedagogical requirements for mobile learning based on Task Model
Researcher: Abdurrahman Jalil
Contact no.: 07440036724

		Please Initial Box
1.	I confirm that I understand about this interview which is designed to gather information for the above study and have had the opportunity to ask questions.	☐
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
3.	I agree to take part in the above study.	☐
4.	I agree to the interview being audio recorded	☐
5.	I agree to the use of anonymised quotes in publications	☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

Appendix B

MOBIlearn2 App Questionnaire

The purpose of this study is to collect the learners' feedback on using the MOBIlearn2 app to support their learning activity through a case study "Attending seminar/workshop". This questionnaire asks about what features in the tool that you have used and are they helpful for your learning. Do NOT write your name on this questionnaire. Your responses will be anonymous and will never be linked to you personally. Your participation is entirely voluntary. If there are items you do not feel comfortable answering, please skip them. Thank you for your cooperation.

Title of the seminar/workshop: _____

Date and Time: _____

Venue: _____

Part 1: Personal information

Please circle the most appropriate response.

1. Gender: a) Male b)Female

2. Please write your age: a) 18 - 30 b) 31 - 40 c) 41 - 50 d) 51 and above

3. Level you are studying at: a) Undergraduate b) Master c) PhD

4. Course/field:_____

5. What type of device that you use: Model_____ OS version:_____

Part 2: MOBIlearn2 app

Please indicate your responses by ticking on the related boxes.

1. Did you take notes using NOTE in the tool? ☐Yes ☐No

If No, skip Question 2-3 and go to Question 4.

2. Did you face any issue or error when using NOTE? ☐Yes ☐No

If Yes, state the issue or error:_____

3. Did you find the note taking feature helpful for your learning? State the reason(s) for your answer.

☐Yes

☐Don't know

☐No

Reason:_____

4. Did you take pictures using PICTURE in the tool? ☐Yes ☐No

If No, skip Question 5-6 and go to Question 7.

5. Did you face any issue or error when using PICTURE? ☐Yes ☐No

If Yes, state the issue or error:_____

6. Did you find the picture taking feature helpful for your learning? State the reason(s) for your answer.

☐Yes

☐Don't know

☐No

Reason:_____

7. Did you record audio using AUDIO in the tool? ☐Yes ☐No

If No, skip Question 8-9 and go to Question 10.

8. Did you face any issue or error when using AUDIO? ☐Yes ☐No

If Yes, state the issue or error:_____

9. Did you find the audio recording feature helpful for your learning? State the reason(s) for your answer.

☐Yes

☐Don't know

☐No

Reason:_____

10. Did you record video using VIDEO in the tool? ☐Yes ☐No

If No, skip Question 11-12 and go to Question 13.

11. Did you face any issue or error when using VIDEO? ☐Yes ☐No

If Yes, state the issue or error:_____

12. Did you find the video recording feature helpful for your learning? State the reason(s) for your answer.

☐Yes

☐Don't know

☐No

Reason:_____

13. Did you sketch image using SKETCH in the tool? ☐Yes ☐No

If No, skip Question 14-15.

14. Did you face any issue or error when using SKETCH? ☐Yes ☐No

If Yes, state the issue or error:_____

15. Did you find the image sketching feature helpful for your learning? State the reason(s) for your answer.

☐Yes

☐Don't know

☐No

Reason:_____

Please write your comment or suggestion for MOBIlearn2 app that you have used (if any):

_____

_____

_____

_____

_____

THANK YOU VERY MUCH

Appendix C

Semi-structured Interview Questions for Case Study 1

1. Briefly describe about the training/event that you have attended?

2. You have installed MOBIlearn2 application in your device. How do you use the app during the event?

3. What features/functions that you think are very helpful for your learning in the event?

4. Is there any difficulty or problem that you have encountered when using the app during the training?

5. Tell me how this app can be improved to support learning activity in that kind of event.

6. Overall, what do you think about this app in assisting your learning goals/objective?

Appendix D

Semi-structured focus group interview questions in Case Study 2

1. Tell me what device you that used (The model and its operating system).

2. What features/components of MOBIlearn2 app that you used during the visit and why?

3. Did you find any error or have any issue when using the app?

4. Generally, what do you think about the design or interface of the app?

5. In your opinion, what are the useful features to learn in that kind of visit?

6. Do you have any comment or suggestion to improve the app for the visit in future?

Appendix E

Designing a mobile learning techno-pedagogical tool based on MOBIlearn task model

Information for Participants

This research aims to understand the experience of students in using a mobile application to support their learning during the exploration of Sheffield Hallam University. We want to understand how students would use the application and its impact on their experience.

Your name and any identifying details will be changed in the transcript to protect your identity when the research is written up.

You have the right to withdraw your data up to one week after the interview. To do this you simply email the researcher and the material will be withdrawn.

If you have any queries, the researcher contact details are given below:

Abdurrahman Jalil, b2040844@my.shu.ac.uk

Thank you.

Please answer the following questions by ticking the response that applies

	YES	NO
1. I have read the information for participants and have had details of the study explained to me.	☐	☐
2. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point.	☐	☐
3. I understand that I am free to withdraw from the study within the time limits, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher.	☐	☐
4. I agree to provide information to the researchers under the conditions of confidentiality.	☐	☐
5. I wish to participate in the study under the conditions set out in the information for participants.	☐	☐
6. I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes.	☐	☐

Participant's Signature: _____ Date: _____

Participant's Name (Printed): _____

Contact details: _____

_____

Researcher's Name (Printed): _____

Researcher's Signature: _____

Researcher's contact details:
(Name, address, contact number of investigator)

Appendix F

Semi-structured focus group interview questions in Case Study 3

1. Tell me what device that you used (The model and its operating system).

2. For Task 1, what features/components of MOBIlearn2 app that you used and why?

3. Did you find any error or had any issue when using the app?

Questions 2 and 3 are repeated for each task.

4. In general, what do you think about the design or interface of the app?

5. In your opinion, what are the useful features to learn in the exploration?

6. Do you have any comment or suggestion to improve the app for performing the tasks?

Appendix G

Sheffield Hallam University

ABDURRAHMAN JALIL <b2040844@my.shu.ac.uk>

Research Ethics Checklist: Framing pedagogical requirements for mobile learning based on Task Model

Whyman, Margaret <scsmaw@exchange.shu.ac.uk> 10 February 2014 at 12:09
To: "Crowther, Paul" <cmspc3@exchange.shu.ac.uk>, "Beer, Martin" <cmsmb4@exchange.shu.ac.uk>, "b2040844@my.shu.ac.uk" <b2040844@my.shu.ac.uk>
Cc: "Adam, Alison" <acesaa3@exchange.shu.ac.uk>

Tracey Holmes passed on the Research Ethics Checklist for the research proposal: Framing pedagogical requirements for mobile learning based on Task Model. I forwarded this to the Chair of the Faculty Research Ethics Committee, Alison Adam, who has confirmed that no further action is required in terms of seeking ethics approval.

Regards

Margaret

Margaret Whyman/Senior Administrator [Business Development and Research Ethics]: Portfolio Team/Faculty of Arts, Computing, Engineering & Sciences/Harmer 2301/tel 0114 225 4234/email M.A.Whyman@shu.ac.uk

Planning and Resources Group Portal

Faculty Research Ethics Committee Portal

SHU Ethics and Governance