5-2014

Empirical Analysis on Factors Impacting Mobile Learning Acceptance in Higher Engineering Education

Yu Huang
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To the Graduate Council:

I am submitting herewith a dissertation written by Yu Huang entitled "Empirical Analysis on Factors Impacting Mobile Learning Acceptance in Higher Engineering Education." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Industrial Engineering.

Xueping Li, Major Professor

We have read this dissertation and recommend its acceptance:

Mehmet Aydeniz, Tami Wyatt, James Ostrowski, Rapinder Sawhney

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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Empirical Analysis on Factors Impacting Mobile Learning Acceptance in Higher Engineering Education

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Yu Huang

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Abstract

Owing to technological advancements and decreasing costs of mobile devices and services, there is a significant change in learning environment that demands for mobility. Such change has enabled a new way of learning, that is, mobile learning. The emergence and prevalence of mobile learning helps flexibility in delivering education, meeting learners' needs, and supporting learning activities without confining to physical locations or time. Mobile learning indicates a new opportunity for education system research and development. The acceptance of mobile learning by students is critical to the successful implementation of mobile learning systems. Therefore, it is important to understand the factors that affect students' perceptions of mobile learning. Encouraged by this new trend in learning, this research employs both quantitative and qualitative research methodologies to explore the factors that affect students' intention to use mobile devices for learning.

Based on the Unified Theory of Acceptance and Use of Technology (UTAUT), this research formulates the factors, including performance expectancy, effort expectancy, social influence, facilitating conditions, self-efficacy, ubiquity, self-management of learning, attainment value, service quality, and perceived enjoyment, and testable hypotheses that are critical to answer research questions and fulfill research objectives. In order to quantify these factors and test research hypotheses, a data collection instrument adapted from previous studies is developed and administered. The results indicate that performance expectancy, perceived enjoyment, ubiquity, service quality, attainment value, and self-management of learning are significant predictors of behavioral intention to use mobile learning; facilitating conditions, social influence, effort-expectancy, and self-efficacy are found to be insignificant.

Additionally, this research examines the differences on intention to use mobile learning across student groups of age, gender, college level, years of using mobile devices, current and planned of mobile device ownership, and prior mobile learning experience via comparison analysis. This research provides university administrators and educators the understandings on the factors that influence student acceptance of mobile learning and the capability to build strategies and policies that incorporate these factors into planning and design phases of mobile learning system implementations.

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Chapter 1

Introduction

Over the past decade, advances in mobile technologies have been unbelievably swift. Enabled by the growth and availability of these technologies, mobile phones are not only a plain tool for voice communication but also serve as a personal digital assistants (PDAs), mini-computer, and camera to capture, transfer, and store rich multimedia contents. These advances in mobile technologies have been recognized as a potential enabler for economic and social development and for strengthening competitiveness (Pachler et al., 2011). Mobile technologies are believed to be the most significant force in shaping education in future and affecting learning and teaching environments, contents and methods, and the educational systems in profound ways (Ryu and Parsons, 2009). With widespread ownership of mobile phones and increasing availability of other portable and wireless devices, the landscape of technology supported learning and the nature of knowledge discourse have been changing and gradually moved toward a new concept of "learning on the go", which is now known as mobile learning or m-learning. The emergence of mobile learning, to some extent, has formed education in its own image and influenced on contemporary higher education systems (Naismith et al., 2004).

Technology has proven to be essential to and positively impacted the educational systems; it plays an significant supplemental role in today's university educational processes (Oblinger and Oblinger, 2005). Communication, information sharing, access to education, and

collaboration between students and between students and instructors have been facilitated by digital and information technology revolutions. Ubiquitous computing offered by mobile technologies has been impacting students' interactions and learning behaviors among themselves and with others in society. It is believed that mobile learning is the next frontier being researched for its potential in enhancing learning and education systems for the students and universities due to the advantages that learning can take place in a variety of contexts, within and beyond traditional learning environments by utilizing any types of mobile devices.

The growing popularity of portable devices and wearable technologies (e.g., iPads, iPod Touch) has provided an opportunity to exploit these technologies for educational purposes, for example, delivering lectures in both audio and video format directly to students (e.g., iTunes U). This trend has also resulted a number of mobile technology-related education projects (e.g., Abt and Tim, 2007; Mantei and Kervin, 2009; Olney et al., 2009). The new generation of smartphones offers mobility of learning contents and has prompted the development of educational applications that exploit the ubiquitous connectivity and high levels of portability (Cochrane and Bateman, 2010; Hall and Anderson, 2009; Schmitt et al., 2009). Advancements in the technology of laptops and tablets and the associated decrease in costs have resulted in these devices becoming increasingly available to most university students and offering a wide range of opportunities for mobile learning innovations in higher education. For example, the U.S. government is seeking to reduce costs by encouraging transition from paper-based to digital textbooks in schools within next five years (Hefling, 2012). Mobile applications (e.g., apps) can be used as learning aids (e.g., anatomical models of human organs for medical students) that students can access virtually from anywhere and communicate with peers and teachers (Young, 2011). Additionally, universities have been shifting their strategies toward focusing on the students and the students' needs due to increasing global competition (Collis and Moonene, 2002; Krause, 2005). In a globally competitive educational system, innovative universities need to promote a culture of change and be willing to adopt new technologies for enhancing the students' learning experiences

so as to stand a better chance of staying relevant and thriving in the new knowledge age (Barone, 2005).

The only way that an innovative information system will reach its full potential is that students and faculties accept and value it. Mobile learning in higher education is still in the beginning stage of implementation, and thus relevant concepts and instructional and technological issues are evolving and require further research (Kukulska-Hulme and Traxler, 2007). Understanding the acceptance and use of mobile learning service is essential to the successful delivery of academic, organizational, and instructional information. Before investing limited funds in developing mobile learning services and contents, it is important that an institution be able to anticipate and account for the factors that influence students' acceptance of a new educational system. If students fail to accept the mobile learning service offered to them, they will fail to use the technology to seek and exchange information, thereby wasting the organizational funds. Furthermore, the university stakeholders need knowledge of students' intentions to use and actual use of mobile devices as well in order to assess academic contents and plan implementation of mobile learning services and support.

1.1 Research Motivation

While there is a growing interest in mobile learning from education industry, the issues regarding how to promote the adoption of mobile learning from both learner's and educational institution's perspectives seem to be largely unsolved. For instance, the availability of various mobile devices for students does not guarantee their use for educational purpose (Corbeil and Valdes-Corbeil, 2007); faculty and support staff acceptance of mobile learning in public schools, colleges, universities, and academic institutions is still low; the determinants of acceptance are not clear despite widespread ownership of mobile devices (Naismith et al., 2004). Consequently, there appears to be an urgent requirement, for educational institutions, to understand the factors influencing students' intentions to use mobile learning in order to retain developing cost and make the mobile learning services acceptable and to be used.

Furthermore, the number of engineering enrollment and the number of successful engineers graduating from educational institutions has been declining seriously over a few years (National Science Foundation, 2012). According to the Accreditation Board for Engineering and Technology (ABET), the engineering graduate does not only require the student to have proficiency with the concepts of science, technology, engineering and mathematics (STEM) but also need to understand the global and economic impact of the gained knowledge. With an extremely demanding for the well-educated engineers, the adoption of mobile technology in education practices is one of the solutions to creating a compelling and yet effective learning experience for the students. However, only a few m-learning implementations were conducted for engineering education; most of them were for language study (Wu et al., 2012; Huang and Zhang, 2012; Hwang and Tsai, 2011). In this sense, this research aims to identify the factors impacting engineering college students' adoption of mobile learning and to explore how these factors will influence universities to promote and implement mobile learning initiatives.

An industrial engineer is, synonymously, a system integrator, a big-picture thinker. System engineering is a management technology to assist and support policy making, planning, decision making, and associated resource allocation or action deployment, which are accomplished by quantitative and qualitative formulation, analysis, and interpretation of the impacts of action alternatives upon the needs perspectives, the institutional perspectives, and the value perspectives of their clients or customers (Sage and Armstrong, 2000). Industrial Engineering, adopted by the Institute of Engineering, is "concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems" (Institute of Industrial Engineers, 2012). Although the term "industrial" is used, it does not only mean manufacturing. Principles, concepts, and techniques of Industrial Engineering have been widely applied in both manufacturing and service industries such as hospitals, banks and education (Turner et al., 1987), and used to evaluate and improve productivity

and quality in service industries as well (Institute of Industrial Engineers, 2012). The evolution and the interlacing of mobile technology in the educational trends have been pushing the entire education system to a new stage. An industrial engineer should take the initiative to apply primary steps of system engineering activities — formulation, analysis, and interpretation of the impact to investigate the determinants of students' acceptance of mobile learning when this new educational paradigm emerges in the instructional and learning process of the education system.

1.2 Problem Statement

Guided by Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), this study primarily focuses on investigating the factors that affect engineering college students' intentions to use mobile devices for learning and identifying applicability of new variables, perceived enjoyment, attainment value, self-efficacy, self-management of learning, ubiquity, and service quality along with UTATU in predicting students' intentions to use mobile device for learning.

Understanding these factors can avoid potential failure in post-implementation. If users are unwilling to accept the new technology, it can lead to non-use, and thus the technology will not bring the intended benefits for the organization (Davis, 1993; Davis and Venkatesh, 1996). The literature has well documented the importance of technology acceptance, and acceptance of technology has been be a primary indicator of usage and success (Davis, 1989; Taylor and Todd, 1995). In higher engineering education, the success of mobile learning depends upon students' acceptance of the technology; therefore, their acceptance should be a key concern for administrators and educators when considering the implementation of mobile learning. Furthermore, attempts to apply technology adoption models to explain students' use and intentions to use mobile learning in an engineering education context have been limited; it requires further investigation to determine whether these models need modifications to address mobile technology acceptance. The following section details the research questions associated with this study.

1.3 Research Questions

Mobile learning is a new educational practice and a new learning style, therefore, more rigorous research is needed to understand the factors driving its promotion among students. As stated in the research motivation, research addressing such issues from a perspective of engineering education is scare. Thus, to determine the factors that is critical to promote and utilize mobile learning in engineering education, there is need to study and evaluate students' acceptance of mobile learning. Therefore, this leads to the following research question:

1. What are the factors that impact students' acceptance on mobile-based learning environment in an engineering education context?

There is a need to identify how students would accept mobile technologies as a learning aid. Hence, the findings from this question can help to determine the students' acceptance on mobile learning and further to determine where resources should be dedicated for implementing mobile learning services in an engineering course, and consequently help to ensure students' learning achievement and success.

2. What are the differences in mobile learning acceptance across students groups?

To deepen the understanding of mobile learning acceptance among student groups, such as age, gender, and prior experience, the answer to this question can help in analyzing demographic differences and thus lead to a more accurate, personalized implementation of mobile learning.

3. How does the use of mobile technologies impact the students' learning process in an engineering education context?

1.4 Research Purpose

The primary objectives of this research are to:

1. Investigate and identify the affordances and constraints involved in mobile learning environment that can support the educators as well as the learners in a capacity that is easy to use, meets the requirements needed and is engaging for the learners.

2. Investigate and identify the factors that impact students' acceptance of mobile learning.

3. Investigate the extend of students' use of mobile learning in learning process, interaction within learning community, resources accessibility, learning attitude, and learning achievement.

4. To examine the relationships between different variables impacting the acceptance of mobile learning.

Achieving these objectives will provide adequate answers to the research questions and insights on implementing mobile learning services to facilitate students to cultivate engineering skills.

1.5 Organization of the Study

This dissertation consists of six chapters. Chapter 1 includes the introduction to the background, motivation, problem statement, research questions and objectives. Chapter 2 reviews the existing literature on educational theories and applications regarding mobile learning. Chapter 3 proposes the research methodology. The chapter first presents the theories on technology acceptance that have influenced this research. Next, the theoretical foundation for this research, related definitions, variables and their relation to mobile learning, and research hypotheses are elaborated. Chapter 4 outlines the research method, including survey population, sampling method, instrument development and validation, as well as the pilot test and final instrument. Chapter 5 covers the statistical analysis methods and details the results of this research that include demographic statistics, reliability analysis, convergent and discriminant validities, factor analysis, correlation and regression analysis for testing the hypotheses, path model, t-tests, and ANOVA tests. Discussion and implication on relevant findings are presented in this chapter as well. Chapter 6 summarizes this research, concludes the discussion and findings, and assesses the limitations and future research.

Chapter 2

Literature Review

2.1 Introduction

Mobile learning has been receiving growing attention in higher education, evidenced by an increasing number of dedicated conferences, seminars, and workshops. For example, mLearn, the first conference on mobile learning, started conference series in 2002 and now has been widely recognized as the premiere international conference on learning with mobile technologies and learning across contexts; IEEE has sponsored the events of the International Workshop on Mobile and Wireless Technologies in Education (WMTE) since 2002. There also have been a rising number of references to mobile learning at generalist academic conferences, such as the Association for Learning Technology conference in every September in UK.

Research in the field of mobile learning is on the rise. Use of mobile technologies is proven to be well aligned with strategic educational goals such as improving student achievement, supporting differentiation of learning needs, enhancing learners' collaboration and interaction, widening learners' participation, and bridging formal and informal learning (Kukulska-Hulme et al., 2009; Sharples, 2000). Some researchers also have devoted great effort to understanding how mobile technologies relate to both traditional and innovative ways of learning and showing the applicability and feasibility of mobile learning across a

wide spectrum of activities (Kukulska-Hulme and Traxler, 2007; Naismith et al., 2004; Faux et al., 2006).

This chapter starts with the definition of mobile learning, which includes the broad and confined terms commonly adopted by the researchers. Next, the applications of mobile learning in higher education industry in terms of contemporary educational theories, including collaborative learning, situated learning, scaffolding, modeling and argumentation, are discussed. Mobile learning affordance and constraints, such as technological advantages and challenges, are presented as well.

2.2 Mobile Learning: M-Learning

By broad definition, mobile learning (also referred as "mobile learning") is, in terms of its technologies, "the explosion of ubiquitous handheld technologies together with wireless and mobile phone network to facilitate, support, enhance and extend the reach of teaching and learning" (M-leanring.org, 2012). These handheld technologies involve connectivity for downloading, uploading and/or online working via wireless and/or mobile networks, and linking to institutional systems, such as virtual learning environments and information management systems. The core platforms for such connectivity usually include mobile phones, smart phones, PDAs, MP3/MP4 players (e.g., iPod), tablets, wireless laptop PCs, mini notebooks or netbooks, and handheld gaming devices (e.g., Sony PSP, Nintendo DS) (Kukulska-Hulme et al., 2009). Enabled by the nature of its technologies, one obvious advantage of mobile learning is the mobility of contents that makes learning take place in any location, at any time, including traditional learning environments such as classrooms as well as in workplaces, at home, in community locations and even in transit (Sharples et al., 2005).

However, the term of "mobile learning" are often confined in the literature to the descriptions of educational applications of mobile handheld devices such as mobile phones, smart phones, PDAs, iPods and MP3 players (Caudill, 2007; Oloruntoba, 2006; Rekkedal and Dye, 2007). The underlying premise, in this case, is that mobile learning occurs

principally with devices that are very small and highly mobile with characteristics such as 'portability' (e.g., mobile phones, iPods). Viewed by this group of researchers, mobile learning is associated only with a particular class of mobile devices. This viewpoint often focuses on handheld devices and excludes laptops, tablets and other larger mobile devices. Therefore, it can limit the boundary of mobile learning applications. Other researchers, adopting the broad definition stated previously, include mobile learning supported by any mobile device that can contribute to learning regardless of size or whether the device is network dependent or not (Millea et al., 2005; Peters, 2007; Wagner, 2005).

In this research, the researcher adopted board definition of mobile learning since the iPads were used in the research context.

2.3 Mobile Learning Application in Education

As a new paradigm of learning emerged with advances in technologies, mobile learning is pedagogically similar to traditional face to face teaching activity, but with stronger demand for rich media leaning contents and learner centered instructional process. Researchers have been investigating a relationship between existing educational theories and how they can be applied and observed in mobile learning. The existing pedagogical and educational practices in mobile learning include collaborative learning, situated learning, scaffolding, modeling, and argumentation.

2.3.1 Collaborative Learning

Collaborative learning describes that learning is promoted through social interaction. Collaborative learning has sprung out from research on computer-supported collaborative work and learning and is based on role of social interaction in the process of leaning (Naismith et al., 2004). In the realm of mobile learning, mobile devices can support and even enhance collaborative learning by providing another means of coordination without attempting

to replace any human-human interactions, such as small group collaborative tasks, ad-hoc networked micorblogging, and co-creation of student artifacts (Chen et al., 2008c; Holotescu and Grosseck, 2011; Kurit et al., 2008; Wong and Looi, 2010; Wyeth et al., 2008). Research undertaken by (Cortez et al., 2004) and (Zurita and Nussbaum, 2004) demonstrated that wireless technologies could obviate the weaknesses of coordination, communication, organization, negotiation, interactivity, and mobility encountered in collaborative learning undertaken without technology. Implementing mobile computing collaborative learning environment in a classroom can also allow instructors to develop pedagogical models that respond to real needs of learners and instructors (Alvarez et al., 2011). Moreover, Stead (2005) stated that in every mobile learning project trial assessed, learners engaged the most with the learning they could undertake together, either by sharing the wireless devices, or by passing data between them; consequently, learning should be built around this. Evidenced by British Educational Communications and Technology Agency (2004), the employment of wireless technologies can assist in increasing collaborative learning and communication, as well as independent learning among those engaged in education, owing to the mobility and the capacity of the devices. As documented by Barker et al. (2005), mobile devices could allow learner groups to distribute, aggregate, and share information with ease, resulting in more successful collaboration. Berger et al. (2003), by drawing an analogy between support for business processes and those in education, contended three success factors, which were quicker reaction, lower costs, and improved quality. Applied this to mobile learning, the indicators of efficiency and effectiveness are that learning materials and course-related information can be distributed and communicated more rapidly; learners can contact peers and lecturers anytime and anywhere; electronic material can be distributed at lower cost and be available at the time and place required for collaborative learning, coordination, and group work. For instance, the study of Maldonado and Pea (2010) showed the encouraging results on the use of low-cost mobile devices in learning ecological science and supporting water quality inquiry by integrating data capturing, multimedia communication and information visualization and creating science collaboration between learners and teachers; in the studies of Spikol and Milrad (2008) and Shih et al. (2011), the learners were able to pull the

information and employ virtual maps corresponding to specific locations in the learning environment via mobile devices so as to fulfill the tasks collaboratively.

2.3.2 Situated Learning

Situated learning has been widely applied in mobile learning owing to location aware function built in many mobile devices. In situated learning, learning activities aim to promote learning within an authentic context and culture (Naismith et al., 2004). It is posited that mobile devices are well suited to context-aware ubiquitous learning environment as they are available in different contexts and can draw on those contexts to enhance the learning activities. Several studies have demonstrated that situated learning supported by mobile technologies and handheld devices can bridge the gap between formal school setting and real-life problem solving and facilitate learners to collaborate and interact with real environment (e.g., Hwang et al., 2010; Ogata, 2008; Pfeiffer et al., 2009; Vavoula et al., 2009). Sharpe (2005) addressed that mobile learning theoretical frameworks should be designed in the way of integrating technologies with learning scenarios. Similarly, Taylor et al. (2006) proposed a dialectic approach of mobile learning based on activity theory that focuses on how technology and learning interact with each other. Hence, in situated learning, mobile technologies should be served as a mediating tool to transfer contextualized knowledge and real-world experiences to learners for supporting learning process and highly efficient understanding of the problems.

With research ongoing for a decade and rapid development, the essence of situated learning assisted by mobile technologies now is about increasing a learner's capability to physically move their own learning environment as they move (Barbosa and Geyer, 2005). In other words, it is characterized by one-mobile-device-per-learner setting and the use of context-aware technologies to transform learners into "nomadic learners". In situated learning environment, mobile devices can function as a ubiquitous knowledge access tool that facilitates just-in-time or contextualized information to serve as evidence to support partially formed ideas or an inquiry process and trigger comparison with previously stored data on the devices (e.g., Rogers et al., 2010).

Additionally, such techno-centric fashion allows learners to interact with both digital and physical worlds. With proper design of learning framework in situated learning, mobile technologies can serve as a stimulus to bring the "presences" of ideas and information to the psychical world, thus enhancing learners' sense making and interaction with reality world (Wong et al., 2010). The potential of such effect is that the use of mobile devices and technologies will become a routine practice and be assimilated to everyday for rapidly connecting ideas and observations in the physical world that are transformed into digital forms for subsequent processing and sharing. Wong et al. (2010) and So et al. (2009) elaborated such learning experience of bridging the gap between physical and digital world in their studies where students made uses of Web 2.0 technology and mobile devices on an ongoing basis to discuss and co-construct knowledge on the artifacts created based on their learning experience during a field trip or in their daily life; their studies both showed the positive results on students' learning achievement and interests.

2.3.3 Scaffolding

In the realm of educational research, the term "scaffolding" refers to the interactive support that instructors, or more skillful peers, offer learners to bridge the gap between their current skill levels and a desired skill level (Sharma and Hannafin, 2007). In this process, by having a "knowledgeable other" or "more capable peer" to support the learner and "share the cognitive load", the amount of support is gradually withdrawn as the learners become more proficient, and ultimately they can complete tasks on their own (Chen et al., 2003). The scaffolding technique has drawn a great deal of interest from educational technology researchers because it can provide a more realistic learning environment with rich and varied support and enable learners to engage in out-of-reach activities. Mobile technology-enhanced scaffolding is capable of creating an interactive, rich media-supported, and individualized learning environment. In addition, scaffolding can help adjust the level of difficulty of problems based on learners' prior knowledge, experience, and abilities. Several researchers have developed mobile-based scaffolding instruction, integrating more than one medium

to support learners' knowledge construction in authentic learning activities (Chen et al., 2003, 2004, 2011; Nussbaum et al., 2009; Sharma and Hannafin, 2007; Huang et al., 2012; Raes et al., 2012). For instance, Chen et al. (2011) claimed that reading comprehension was significantly higher in a technology-enhanced setting after receiving scaffolding reading training than their counterparts who did not received scaffolding reading training. Nussbaum et al. (2009) introduced mobile technology as a collaborative scaffold that guided and mediated the interactions between students as they worked through a structured sequence of information sharing and knowledge construction, beginning with individual participation, then moving to group collaboration, and lastly finishing with a teacher who mediated whole class discussion. With such face-to-face collaborative scaffolding, students experienced greater interaction with their group members on open-ended tasks in a technology-mediated learning context. Apart from instructional purpose, Shih et al. (2010b) proposed a self-regulated learning (SRL) system with scaffolding support in order to provide a form of "mobile scaffolding" that could let learners easily access to learning contents and resources, build schedules, and monitor learning processes. This study provided some positive results on guiding student toward independent self-management and creating a personal mobile support context for learning and doing.

However, Chen et al. (2003) and Sharma and Hannafin (2007) stated that a major challenge in technology-enhanced learning was to determine when the support should be withdrawn and how much the support should be reduced, so as to enhance the independence of learners. To overcome this challenge, it is essential to assess the ongoing state of students' knowledge mastery level at any point during the scaffolding process in order to bridge their capacity to inquire and fade support as students learn to accomplish their problem-solving goals without scaffolds (Kim and Hannafin, 2011). Also, scaffolding with mobile technologies needs to focus on creating opportunities and experiences necessary for learners to become capable, self-reliant, and self-motivated learners so that independent learners can develop the values, attitudes, knowledge, and skills needed to make responsible decisions and take actions dealing with their own learning.

In terms of scaffolds design, Sharma and Hannafin (2007) pointed out that technology-enhanced scaffolding research and practice should incorporate two distinct yet complementary design components, that is, cognitive design and interface design. Cognitive design explicates and communicates underlying thinking processes and products in the achievement of a learning goal, while interface design focuses on representational formats that accurately and efficiently convey the cognitive intent of the scaffolds (Sharma and Hannafin, 2007). Therefore, in implementation of scaffolding with mobile technologies, the scaffolds design needs to be consistent with learners' understanding and cognitive development and carefully crafted to promote both task completion and reasoning skills so as to reduce the possibility of unintended interpretations of a scaffold's intent. Additionally, one issue with scaffolding is that it is sometimes complicated by students' limited scientific background, experience, and knowledge (Kim and Hannafin, 2011). To overcome such issue, scaffolding with mobile technologies should consider providing tools to visualize numerous, complex variables via scenario-based games, or simulating how variables are related using graphs, to engage learners and cultivate their reasoning and problem solving skills.

2.3.4 Modeling and Argumentation

A model, as cited by Schwarz et al. (2009), is "an abstract, simplified representation of a system of phenomena that makes its central features explicit and visible" (Schwarz et al., 2009, p. 634). Scientists develop models of natural phenomena through careful and systematic observations and analyses of the results of their observations. Analysis of empirical evidence "gives insights into potential elements, relations, operations and rules within a model" (Schwarz et al., 2009, p. 633). Modeling consists of a set of scientific practices that involve various activities, such as identifying variables, making connections among variables, testing and verifying the accuracy of the model (Jackson et al., 1996). Modeling is an effective way to help learners to understand the nature of science, improve their problem solving skills, and help them to develop higher order thinking skills (Jackson et al., 1996).

Another pedagogical approach deemed important for students' learning of core science and engineering concepts is argumentation. Argumentation refers to "the process of constructing, testing, and revising understandings through public debates about how to best explain the phenomenon under study" using the epistemic and social norms of science (Berland and Reiser, 2008, p.28). This view of science and science learning posits that "explanations and models of scientific phenomena are constructed through social discourse in which these "explanations and models are questioned, evaluated, and revised. In other words, in scientific communities, explanations are developed through argumentation" (Berland and Reiser, 2008, p.28).

Modeling and argumentation pedagogical practices or learning activities are rarely incorporated in mobile learning systems or platforms. However, researchers and practitioners have been interested in developing technology-enhanced inquiry that especially considers the affordances of mobile technologies and to an extent assumes the role of modeling and argumentation in science and engineering education (e.g., Chen et al., 2008b; Hung et al., 2010; Liu et al., 2009a; Looi et al., 2010; Maldonado and Pea, 2010; Reynolds et al., 2010; Shih et al., 2010a; Vavoula et al., 2009). During such inquiry activities, the students can collect and analyze data or take notes when observing the objects, and then instructors will guide students to use gathered information to reflect on and reason related scientific concepts or phenomena.

This technology-enhanced inquiry provides the opportunity to use mobile technologies in modeling or argumentation. For example, provided with mobile inquiry "toolkit" and associated hardware for collecting data, learners can conduct the inquiry and then later be guided through a process of posing inquiry questions, gathering and assessing evidence, conducting experiments, and engaging in informed debate. From engineering education perspective, the technology-enhanced inquiry aims to mobilize or transform conventionally content-centered and teacher-centered, or perhaps paper-based curriculum to a systematic student-centered infrastructure that can foster students' skills on reflection, reasoning and problem-solving (Cathleen and Soloway, 2008; Looi et al., 2009). In addition, Wichmann et al. (2010) stated the three perspectives on the technology-enhanced inquiry, which were

personal inquiry, mobile collaboratories and emerging learning objects. In other words, personal inquiry stresses on students' responsibilities and ownership of their own inquiries for the purpose of personalized learning and independent learning; mobile collaboratories and emerging learning objects involve the collaborative and situated learning, such as group data collection or measurement in an authentic learning environment. With instructors' guidance during or at the final stage of the learning activities, the goal is that learners are able to draw conclusions or conduct experiment on their own (e.g., Maldonado and Pea, 2010; Scanlon et al., 2009; Vavoula et al., 2009).

2.4 Mobile Learning Affordances

The most important and primary benefit of mobile learning is that the devices are portable. This primary benefit removes temporal and spatial limitations of learning and allows students and faculties to organize their time more effectively by extending access to course related information, communication, and collaboration (Naismith et al., 2004). Continual connectivity to information encourages more flexible access and engagement in learning and knowledge sharing (Alexander, 2004; Kukulska-Hulme and Traxler, 2007). This can extend into more contextual situations for students by enabling them immediate communication and dissemination of information (e.g., text, email, video, discussion boards) and access to information sources (Motiwalla, 2005; Sharples, 2000).

Identified by Kim et al. (2006), three key benefits to the educational use of mobile technologies include management of electronic information, real time file sharing, and portable and wireless connectivity. For example, with the wireless connectivity, free or inexpensive mobile applications, and network processing power, synchronization of data, data storage and access, and data sharing are possible without a PC (Avraamidou, 2008). This synchronized and ready access to data, learning content, and reference tools can help remove barriers to learning activities and support independent and collaborative learning. Furthermore, mobile learning supports social inclusion and a sense of community that are important issues in society and education systems and helps overcome the digital divide for

learners who do not have access to computers but typically own a mobile phone (Kadirire, 2007; Naismith et al., 2004). Social presence strongly affects learner satisfaction, and increased communication can enhance social presence. Mobile learning has been implemented to support social presence and peer discussions (DuVall et al., 2007). Feedback, engagement with contents, and opportunities for building a sense of community could be greatly enhanced by mobile devices. Students and faculties can communicate and interact at their convenience.

The flexibility of mobile access to information extends learning into authentic and contextual situations and facilitates lifelong learning, knowledge sharing, information seeking, and personalized activities, by providing portable, flexible, and wireless access to research tools, information and communication (Chen et al., 2003; Naismith et al., 2004; Vavoula and Sharpe, 2002; Sharples, 2000). For example, Naismith et al. (2004) suggested that mobile phones could increase possibilities to engage in informal learning not tied to a specific physical location or formal educational settings like a library, computer lab, or classroom. Moreover, mobile devices can enable a flexible, convenient, personalized, secure, and easy to access content interface (Caudill, 2007; Fozdar and Kumar, 2007). Caudill (2007) suggested that mobile learning could reduce the time needed to manage resources and "ease of access" could streamlines the learning process for the learner and provide students with an opportunity to engage with technology that they were familiar with and to use in their everyday lives.

Extended by Cheung and Hew (2009), mobile learning mobile devices can function as following learning tools that empirically address the benefits of mobile learning.

1. A communication tool for learners to communicate and collaborate with their peers and instructors via e-mails, phone calls, SMS and blogging (e.g., Brandt et al., 2009; Kert, 2011; Holotescu and Grosseck, 2011; Huang et al., 2009).

2. A multimedia access tool for learner to access multimedia resources such as ebooks, web pages, audio and video files and PowerPoint presentations, for example, iTunes U. Especially, with location aware such as GPS, radio frequency identification (RFID) tag or QR codes in some cases, learners can use mobile devices to access the information

corresponding to or interact with the objects their surroundings for further suited context-aware learning, which is commonly used in situated learning (e.g., Chen et al., 2003, 2011; Hwang et al., 2010; Liu et al., 2009b; Ogata, 2008; Pfeiffer et al., 2009; Shih et al., 2011; Vavoula et al., 2009).

3. A capture tool for learners to gather various types of data for follow-up learning. For example, learners can use inbuilt cameras of mobile devices to take the photos of classrooms and field trips, record the episodes of lectures and audio narrations or conversations (e.g., Ferry, 2009; Hoban, 2009; Lan and Tsai, 2011).

4. A representational tool for learners to create representations, demonstrations or showcase about their ideas, thinkings, experiences, reflections and knowledge (e.g., Chen et al., 2008a; Marty et al., 2012; So et al., 2009; Vavoula et al., 2009).

5. An analytical tool for learners to manipulate certain data or variables (e.g., Maldonado and Pea, 2010; Wong et al., 2010).

6. An assessment tool for learners to take examinations, tests or quizzes (e.g., Franklin et al., 2007; Segall et al., 2005; Treadwell, 2006; Triantafillou et al., 2008). Besides functioning as an assessment tool, Segall et al. (2005), Treadwell (2006), and Triantafillou et al. (2008) also examined usability of mobile devices.

7. A task management tool for learners to store and organize address books, contact information, schedules, task lists or homework submission (e.g., Corlett et al., 2005; Shih et al., 2010b; Stone, 2004; Yau et al., 2010).

In some studies, mobile devices function as multiple-type of tools. For example, in the study of Vavoula et al. (2009), the students used mobile devices as a multimedia access tool to pull the information on the collections in the museum and then created their own collections and wrote thoughts on the devices as a representation tool.

2.5 Mobile Learning Constraints

Despite unique advantages, there are some constraints that limit the capability of mobile learning. In the aspect of usability, screen size, battery life, storage, and slow downloading are several constraints related to mobile learning (e.g., Georgiev et al., 2004; Corlett et al., 2005; Franklin et al., 2007). For example, some studies identify usability issues like small keyboards as a constraint to mobile learning (Sharples et al., 2002; Wentzel et al., 2005). However, technology advancements in virtual keyboards may address this issue (Georgiev et al., 2004). Small screen size can cause viewing cumbersome, eyestrain, or be difficult for vision impaired individuals. In addition, web pages are not always designed for small screens (Alexander, 2004; Bachfischer et al., 2008). Limited storage and memory, and document editing capabilities may also limit mobile academic activities (Shudong and Higgins, 2005). While some applications, such as Pages, allow mobile document editing, small keyboard and screen size is still cumbersome (Shudong and Higgins, 2005). This indicates that student mobile learning activities with limited typing requirements may be ideal for mobile learning. Moreover, colleges' learning management systems (LMS) such as Blackboard may present another technical issue. For example, an LMS may not have all of the course content formatted for mobile devices; online storage for course materials may be limited; or IT administrators may be reluctant to modify the systems to address mobile access.

Limited availability of broadband wireless access may be also prohibitive for mobile learning implementation (Bachfischer et al., 2008). To ensure network connectivity, researchers have suggested engineering a pure connection and pure mobility mode for the mobile device so that it can download and store what is needed for most of the learning process and be able to function with minimal or no connection for long periods of time (Orr, 2010). In this case, the mobile device turns into a small computer with no communication function. The effort in developing an application that can be used for a broad selection of mobile devices is nowhere near that of developing for regular computers. The lack of cross-platform consistency in mobile devices is another drawback in mobile learning, unless an entire industry or university is using the same device (Orr, 2010). Multitasking sometimes

also causes mobile learner's distraction, which consequently compromises the retention of learning contents (Dolittle et al., 2009).

The cost of mobile devices and services is another consideration. Some studies identified both the cost imposed by telecommunications for access and mobile devices to be primary cost barriers for students (e.g., DuVall et al., 2007; Georgiev et al., 2004; Savill-Smith and Kent, 2003).

2.6 Summary

In sum, the literature review on mobile learning research indicated that mobile learning could enhance the learning process through increased access anywhere, anytime in different contexts and offered a consensus view on its advantages and limitations. To implement mobile learning successfully, the educational institutions are responsible for understanding how to best use mobile devices for educational purposes and taking advantage of what these devices offer in mobility and convenience. This opportunity especially exists in higher education as the student population is one of the largest portions of society with the highest percentage of mobile devices ownership, especially smartphones.

In order to understand how to best use mobile devices for learning, the first step is to understand the students' perceptions of using these devices for learning and education. User perceptions and acceptance of mobile device usage in educational settings, whether direct, as in course materials, or indirect, as in course and university administration, is an important component of a complete and comprehensive model of mobile learning. User perceptions and perceived acceptance of mobile learning by students can provide information needed by universities and educators to make better decisions regarding mobile learning implementation. In next chapter, theoretical foundation for developing research model is discussed, and research hypotheses are formulated based on the research model.

Chapter 3

Methodology

3.1 Introduction

The theoretical foundation for the research model and hypotheses are presented in this chapter. In the following, special attention is given to Unified Theory of Acceptance and Use of Technology and Technology Acceptance Theory in relevance to the research questions and in order to generalize factors that possibly impact students' perceptions of mobile learning. Building on the literature and previous research, a set of variables used for formulating students' acceptance of mobile learning are identified. Research hypotheses are formulated in relation to these variables. The related components for implementing mobile learning in a university environment are presented as well.

3.2 Unified Theory of Acceptance and Use of Technology (UTAUT)

Acceptance of a new information technology or system has been shown to be a prerequisite to a successful implementation of such a system; thus, determinants of user acceptance can contribute to enhancing system design and impacting effectiveness of the system (Davis, 1989; Mathieosn, 1991a; Agarwal and Prasad, 1998). How users' perceptions toward a system

influence the acceptance and how individuals adopt these new systems has long been an active area of research (Venkatesh et al., 2003). Identified by Venkatesh et al. (2003), there are eight prominent models designed to explore technology acceptance: (1) Theory of Reasoned Action (TRA), (2) Technology Acceptance Model (TAM), (3) Motivational Model (MM), (4) Theory of Planned Behavior (TPB), (5) Combined Technology Acceptance Model and Theory of Planned Behavior (C-TAM-TPB), (6) Model of PC Utilization (MPCU), (7) Innovation Diffusion Theory (IDT), and (8) Social Cognitive Theory (SCT).

However, Venkatesh et al. (2003) noticed that researchers were confronted with a choice among a multitude of models and were bound to choose a favored model, thus ignoring the contribution from alternative ones. They felt the need for a synthesis in order to reach a unified view of users' technology acceptance and incorporate the core constructs of intention to use and usage of technology from the numerous information systems usage behavior models available. Hence, Venkatesh et al. (2003) reviewed and compared the eight dominant models, including TRA, TAM, MM, TPB, C-TAM-TPB, MPCU, IDT, and SCT, and provided the theory of Unified Theory of Acceptance and Use of Technology (UTAUT) as the synthesis of eight primary models. The UTAUT theory seeks to explain intentions to use an information system and subsequent usage behavior. The theory holds that key constructs of performance expectancy, effort expectancy, social influence, and facilitating conditions are direct determinants of information system usage intention and usage behavior, and gender, age, experience, and voluntariness of use moderate the impact of the four key constructs on usage intention and behavior (Venkatesh et al., 2003). Fig.3.1 illustrates the UTAUT model. As a summary, Table 3.1 lists the description of each independent variable in UTAUT model, underlying constructs under each independent variable, and corresponding models from which they are taken (Venkatesh et al., 2003).

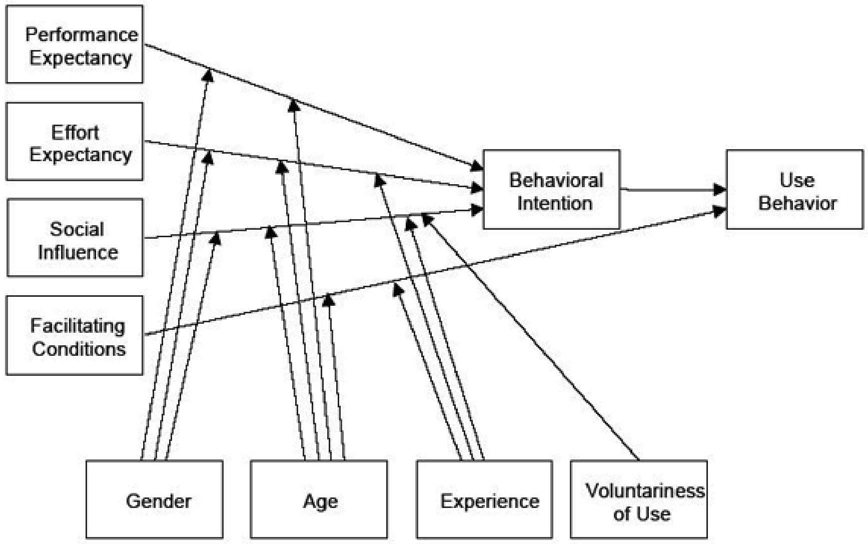

Figure 3.1: UTAUT model (Venkatesh et al., 2003)

Table 3.1: Summary of UTAUT model

Variable	Description	Construct	Corresponding Model
Performance Expectancy	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.	Perceived Usefulness; Extrinsic Motivation; Job Fit; Relative Advantage; Outcome Expectations	C-TAM-TPB, TAM/TAM2, MM, MPCU, IDT, SCT
Effort Expectancy	The degree of ease associated with the use of the system	Perceived Ease of Use; Complexity; Ease of Use	TAM/TAM2, MPCU, IDT
Social Influence	The degree to which an individual perceives that important others believe he or she use the new system.	Subjective Norm, Social Factors, Image	TRA, TAM2, TPB/DEP
Facilitating Conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.	Perceived Behavioral Control; Facilitating Conditions; Compatibility	TPB/DTPB, C-TAM-TPB, MPCU, ID

3.3 Technology Acceptance Model (TAM) and Its Extension

TAM is a model that describes the antecedents of the adoption of information technology and is considered as a robust tool for measuring the adoption of new technology by users (Agarwal and Prasad, 1999; Davis, 1989; Doll et al., 1998; Segars and Grover, 1993). Over the years TAM has been validated by various applications and extensions, such as web-based information systems (Van der Heijden, 2003; Yi and Hwang, 2003), Internet banking, and electronic commerce (Wang et al., 2003; Henderso and Divett, 2003; VanDolen and DeRuyter, 2002). Additionally, TAM has been applied to many different end-user technologies, such as email, word processing, spreadsheets, the World Wide Web, ubiquitous computing, and mobile payments (Adams et al., 1992; Davis, 1989; Lederer et al., 2000; Agarwal et al., 2000; Viehland and Leong, 2010; Yoon and Kim, 2007). Fig.3.2 illustrates TAM model, which includes six constructs, namely external variables (EV), perceived usefulness (PU), perceived ease of use (PEOU), attitude (A), behavioral intention (BI), and actual system usage. It shows that user behavior is determined by perceived usefulness (PU) and perceived ease of use (PEOU) of the technology (Adams et al., 1992; Davis, 1989; Davis et al., 1989; Mathieosn, 1991a).

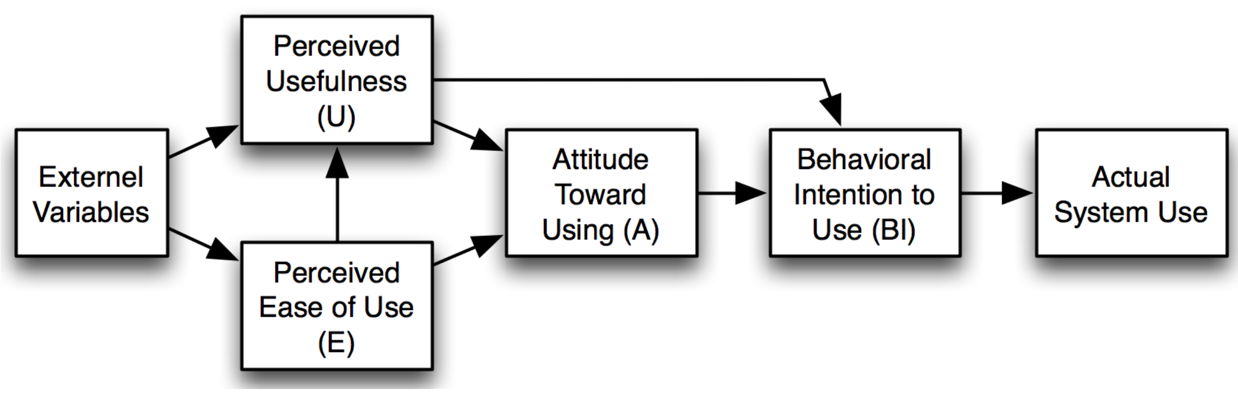

Figure 3.2: TAM model (Davis et al., 1989)

In TAM, PU is defined as an individual's perception that using a new technology will enhance or improve her/his performance (Davis, 1989, 1993). Applying this definition to mobile learning, PU means a user's perception that using mobile learning enhances their learning performance. By TAM theory, a strengthening of this belief creates a positive attitude toward mobile learning, thereby increasing the user's intention to use mobile learning and subsequent usage. PEOU is defined as an individual's perception that using a new technology will be free from effort (Davis, 1989, 1993). In the context of mobile learning, PEOU represents the perception that mobile learning is easy to use. TAM establishes a theoretical basis for explaining causal links between these two key constructs and user attitudes toward use of technology, behavioral intentions, and actual system usage. Malhotra and Galletta (1999) defined attitude as the user's desirability of his or her using the system. By Hu et al. (1999), Venkatesh et al. (2002), and Wang et al. (2003), PU and PEOU are the determinants of attitude toward the system; attitude and PU are the predictors for behavioral intentions; actual system usage is predicted by behavioral intentions; PEOU is hypothesized to be a predictor of PU; both PU and PEOU are affected by external variables. The external variables in the model refer to a set of variables such as objective system design characteristics, training, computer self-efficacy, user involvement in design, and the nature of the implementation process (Davis, 1986).

However, as TAM continued to evolve, new variables are introduced as external variables affecting PU, PEOU, BI, and actual system usage or behavior. Among the most frequently referenced are system quality, compatibility, computer anxiety, enjoyment, computing support, and experience (Lee et al., 2003). The relationship between TAM's four major variables (PU, PEOU, A and BI) is hypothesized to use PU both as a dependent variable affecting BI directly and as an independent since it is predicted by PEOU. Actual Use or BI is usually measured by amount of time using, frequency of use, actual number of usages and diversity of usage.

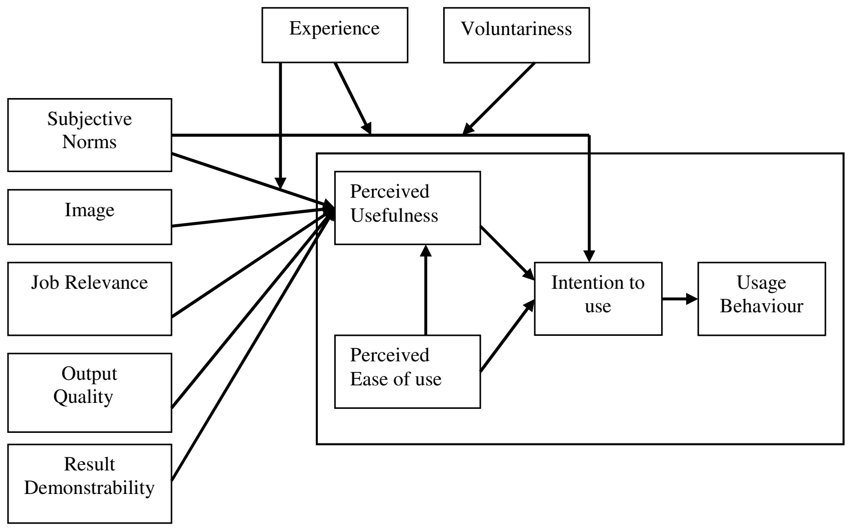

Figure 3.3: TAM2 model (Venkatesh and Davis, 2000a)

In effort to enhance TAM, Venkatesh and Davis (2000a) extended the original TAM model to explain perceived usefulness and usage intentions in terms of social influence and cognitive instrumental processes. Since TAM's introduction, consequent studies have built on TAM's promising robustness, trying to compare TAM to its origins and with other models used in explaining technology acceptance. Previous studies agreed upon the need for adding other variables to serve as determinants of the major constructs since the original model lacked such determinants for PU and PEOU (Venkatesh and Davis, 2000a). As a result, TAM2 is an extension of TAM, which includes additional key determinants of PU and usage intention constructs that are meant to explain the changes in technology acceptance over time as individuals gain experience in using the targeted technology. Fig.3.3 shows the model referred to as TAM2.

TAM2 incorporates additional theoretical constructs covering social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use). Unlike TAM, TAM2 and UTAUT make a distinction between voluntary and mandatory usage. Researchers suggested that usage intentions vary even when a change is organizationally mandated (Hartwick and Barki, 1994). In addition, TAM2 considers that mandatory system acceptance approaches appear less effective over time than social influence (Stam et al., 2004). Subjective

norm is an individual's perception that the majority of those who are important to him/her believe he/she should or should not perform the behavior (Venkatesh and Davis, 2000a). TAM2 theorizes that in a mandatory setting, the direct compliance-based effect of subjective norm on an individual's behavioral intention is above that of perceived usefulness and perceived ease of use. However, it is suggested that this is not the case in voluntary system usage settings (Venkatesh and Davis, 2000a). Voluntariness is the level to which an individual can choose to use a system; image is the extent to which individuals believe the use of a system will increase their social status within a group or how well others perceive them; output quality is the degree to which an individual believes that the system performs his or her job tasks well (Venkatesh and Davis, 2000a). TAM2 proposes that subjective norm will be positively influence by image. Job relevance is an individual's perception of the degree to which a system is applicable to his or her job (Venkatesh and Davis, 2000a). TAM2 states that because users are the ones with the best perception of what is needed to successfully complete their work, this knowledge will provide them with a clear understanding of how useful a system.

3.4 Limitations of UTAUT and TAM

UTAUT, TAM and TAM2 are originally developed to describe and explain organizational adoption of information technologies, but the mobile technology adoption is more individual, more personalized and focuses on the services made available by the technology (Carlsson et al., 2006). A long list and the variety of factors have been investigated by researchers in order to understand the essence of user acceptance and perceptions in relation to different mobile services. Due to a wide variety of services within the spectrum of mobile services and their unlimited use contexts, the scope of combining existing variables and adding new ones by each study is as a result extensive (AlHinai and Johnstion, 2007). In some research, the newly-added variables posit stronger explanatory capabilities than the ones from original model structure particularly within the context of mobile services (e.g., Ha et al., 2007; Mallat et al., 2008; Liu and Li, 2011). Hence, it is critical and essential to integrate

mobile technology-specific features into the traditional adoption models (Mallat et al., 2008). Additionally, UTAUT is a relatively new framework and needs additional research to replicate findings and validate its measures and robustness (Straub, 2009). Although UTAUT has been validated in subsequent information system research, there are still areas open for further research to address technology that may fall within the 30% unexplained acceptance and account for invariance of the UTAUT scales across different cultures, populations, and novel applications (Baron et al., 2006; Li and Kishore, 2006; Venkatesh and Morris, 2000; Venkatesh et al., 2000, 2003). Furthermore, UTAUT does not include individual factors like perceived playfulness and self-motivation that may help explain information system acceptance and use of mobile devices (Mallat et al., 2008).

TAM and TAM2 are models applicable to a variety of technologies, yet they have been criticized for not providing adequate information on individuals' opinions of information systems (Mathieosn, 1991b; Moon and Kim, 2001; Monsuwe et al., 2004). Both TAM and TAM2 make assumptions related to the use of technology that may not apply outside of the workplace (e.g., university); such as, all individuals have access to adequate equipment and an information system and are mandatorily required to use the system. In other words, TAM and TAM2 are designed for measuring usage in the workplace where voluntariness of use may not be under an individual's control. In contrast, the use of academic information systems and mobile learning applications, such as ebooks, library databases, and podcasts, is mostly voluntary. As to external variables, Davis et al. (1989) observed that external variables enhanced the ability of TAM to predict acceptance of future technology, which means the constructs of TAM need to be extended by incorporating additional factors depending on the target technology, main users, and context (Moon and Kim, 2001). Also, Wang et al. (2003) noted that variables relating to individual differences played a vital role in the implementation of technology. Another commonly reported limitation of TAM is the measurement of usage by relying on respondents' self-reporting usage and assuming that self-reported usage reflects actual usage (Mathieosn, 1991b). Other limitations, such as a variety of types of respondents or the sample choices that made generalization difficult and limited guidance about how to influence usage through design and implementation, are also

addressed in some studies (Taylor and Todd, 1995; Legris et al., 2003; Venkatesh et al., 2003). Additionally, TAM provides feedback on usefulness and ease of use but does not provide feedback about aspects of improvement that might enhance the use of technology such as flexibility, integration, completeness of information, and information currency. Such guidelines were at the core of TAM development but failed to receive the appropriate attention (Davis, 1989).

Other researchers stated two major shortcomings of TAM studies: the explanatory power of the model and the inconsistent relationship among constructs (Sun and Zhang, 2006; Venkatesh et al., 2003). For example, Sun and Zhang (2006) examined the data from 55 articles chosen according to certain criteria indicated the vulnerability of explanatory power in two areas: the relatively low explained explanatory power of the model and the variation of explanatory power due to different methods used (e.g., field versus experimental studies). The indicated limitation is that the relationships between the major constructs of TAM showed an inconsistent pattern. In some studies the relations were statistically significant, indicating TAM as a robust model, while other studies showed the opposite. For example, the effects of PEOU on attitude, behavior intentions, and usage were inconsistent. In addition, the relationship between PEOU and PU was significant in most studies. However, there were exceptions to that relationship, the reasons of which were attributable to the type of users or their experience. Such as, professional users have different intellectual capacities, and more experienced users less likely have the effect of PEOU on PU (Lee et al., 2003).

Comparing to UTAUT, TAM does not consider organization and system variables that may negatively impact an individual's usage of an information technology such as individual financial cost, system characteristics, training, and management support (Handy et al., 2001). UTAUT addresses the issues with the social influence, facilitating conditions, experience, and voluntariness constructs. In relevance to mobile learning and students, the cost of a mobile device and the corresponding costs can be prohibitive. Students with limited income would need to weigh the benefits and ease of use with the disadvantage of cost. Thus, UTAUT seems applicable in regard to understanding students' acceptance and use of mobile learning. Researchers have demonstrated UTAUT to be a valid and reliable

theory for the acceptance and use of information technology and encouraged future research to explore UTAUT in different contexts (Venkatesh et al., 2003). However, researchers, such as Wang and Shih (2008b), suggested that fundamental constructs of UTAUT might not fully reflect the unique influences of mobile technologies that may alter a user's behavioral intention to use and actual usage of mobile services. Pedersen and Ling (2003) also suggested that traditional technology adoption models may be modified and extended when researching technology adoption of mobile services. Therefore, to identify the factors impacting students' acceptance of mobile learning and their implications on learning process and interactions, proper modification for original UTAUT model is necessary so as to integrate the variables reflecting the unique characteristics of mobile learning, such as ubiquitous connectivity and personalization. This leads to the discussion on research model in the following.

3.5 Research Model

A theoretical framework is a conceptual model of how one theorizes or makes logical sense of the relationship among the factors that are identified as important to the problem; from the theoretical framework, testable hypotheses can be developed to examine whether the theory is valid; the hypothesized relationship can thereafter be tested through appropriate statistical analysis in order to ensure the validity of the research Sekaran (1992). Since the theoretical framework identifies the network of relationships among the variables that are important to the study, it is essential to understand what variables are involved. As such, a research model is developed in this section based on theoretical foundations provided previously.

As previously stated, traditional UTAUT model needs proper modification to include the features of mobile technologies. Thus, in addition to the four core constructs of UTAUT, six additional determinants associated with the unique characteristics of mobile learning are integrated, they are, self-efficacy, ubiquity, attainment value, service quality, perceived enjoyment, and self-management of learning. The proposed research model is shown in Fig.3.4. The description of each key variable and rationales are described as follows:

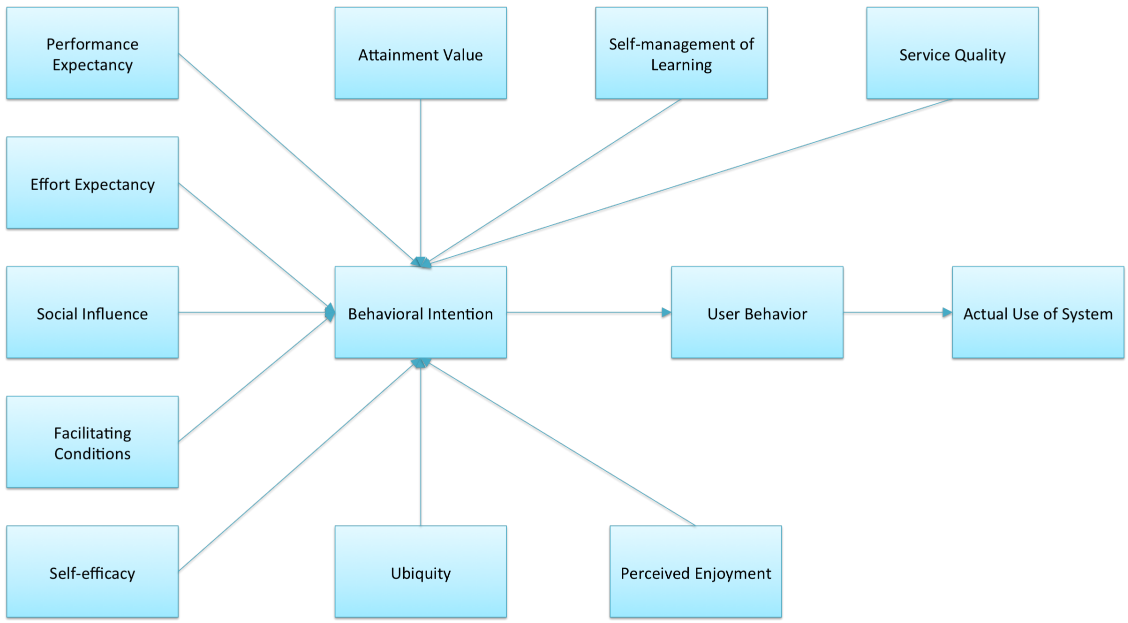

Figure 3.4: UTAUT model in the context of mobile learning

- Performance expectancy is defined as the degree to which an individual believes that using a particular system will help him or her to attain gains in job performance (Venkatesh et al., 2003). Researchers have demonstrated a positive relationship between performance expectancy and behavioral intention (Venkatesh et al., 2003). Hence, adapting performance expectancy to the context of mobile learning suggests that individuals will find mobile learning useful due to convenient access to information without the restriction on physical locations and time.

- Effort expectancy, closely related to perceived ease of use in TAM, is considered as the degree of ease associated with the use of the particular information system (Venkatesh et al., 2003). To the extent that promoted effort expectancy leads to improved performance, previous studies indicated that effort expectancy had a direct effect on performance expectancy and intention to use mobile learning (Carlsson et al., 2006). In addition, Davis (1989) and Venkatesh (1999) stated that an effort-oriented construct was expected to be more salient in the early stages of a new behavior. Since mobile learning is still in its early stage, it is believed that effort expectancy will be

an important factor of behavioral intention to use mobile learning. Therefore, effort expectancy is included in the research model.

- Social influence is defined as the degree to which an individual perceives that important others believe he or she should use the new system (Venkatesh et al., 2003). Previous literature suggested social influence was a strong predictor of behavioral intention in shaping an individual's intention to use new technology systems (Morris and Venkatesh, 2000; Venkatesh, 2000; Venkatesh et al., 2003). In the context of mobile learning, it indicates that social influence will strongly affect students' intention to accept and use mobile devices for academic purposes. As a learner's decision is also influenced by others, such as peers or instructors (Miller, 2003; Shen et al., 2006), and thus it is rational to include social influence for evaluation.

- Facilitating conditions refer to the availability of resources needed to engage in a behavior, such as time, or money. Wang and Shih (2008a) found that facilitating conditions had a significantly positive effect on an individual's use of an information system. Concannon et al. (2005) also emphasized the importance of providing students with guidance and technical support to facilitate engagement with learning technologies. In the context of mobile learning, learner's satisfaction and decisions are affected by the perception of support from learning material providers, functionality of personal devices, and so forth. Hence, facilitating conditions appear to be an essential factor.

- Self-efficacy refers to the personal belief in one's own ability to complete tasks and reach goals (Schunk, 2008). In the context of mobile learning, it indicates an individual's perception of his or her capability to use mobile device to engage in learning tasks, locate and manipulate information, and communicate and collaborate using social technologies. Hence, self-efficacy is also included in the study.

- Ubiquity is the most significant feature of mobile learning and the main advantage of mobile learning in comparison to traditional educational approaches (Naismith et al.,

2004). Previous studies suggested importance of ubiquitous access in affecting user's decision to adopt particular mobile services (Kaigin and Basoglu, 2006; Mallat et al., 2008; Wang and Li, 2012), and therefore it is necessary to involve ubiquity in the study.

- Attainment value is, defined by Eccles (1983), personal importance of doing well with regard to self-schema and core personal values, such as achievement. According to Eccles and Wigfield (2000), tasks will have higher attainment value to the extent that they allow the individual to confirm salient aspects of learner's self-schema. Chiu and Wang (2008) indicated a positive relationship between attainment value and continuance intention from a perspective of technology-enhanced learning. Accordingly, the learner's decision regarding the use of mobile learning may be influenced as well by perceived attainment value. Thus, attainment value is introduced in the study.

- Self-management of learning refers to the extent to which an individual perceives he or she is self-disciplined and enables to engage in autonomous learning (Smith et al., 2003). Successful learning is derived from learner's control of the learning activity, exploration and experimenting, asking questions, and engaging in collaborative argumentation (Sharpe, 2003). According to Evans (2000) and Smith et al. (2003), the need for self-direction or self-management of learning runs clearly across the distance education and resource-based flexible learning literature. Since mobile learning can be considered as a kind of e-learning via mobile devices, it is expected that an individual's level of self-management of learning will have a positive influence on his or her behavioral intention to use mobile learning. Additionally, in the context of mobile learning, students may manage their own learning as they are sometimes separated from faculty, peers, and the institutional support. This autonomy entails an increased need for skills in critical thinking, identify learning needs, and locating and evaluating resources (Li, 2010; McFarlane et al., 2007; Wang et al., 2009). As a result, self-management of learning is included in the study.

- Service quality refers to reliability, content quality, personalization. Daft and Lengel (1986) suggested that accuracy, reliability, and quality of information exchanged across a medium were critical to the effectiveness. In the context of mobile learning, the content refers to information, features, or functions that are offered via mobile learning services. Such content should be constructed logically to help learners find information and incorporate features such as accuracy, timeliness, relevance, and flexible presentation (Huizingh, 2000). A reliable mobile learning system should ensure the effectiveness of mobile learning, and therefore service quality is included in the study.

- Perceived enjoyment pertains to the intrinsic motivation factor in the TAM model added by Moon and Kim (2001), referring to an individual's performance or engagement in an activity due to his or her interest in the activity. Some studies have shown that perceived enjoyment is a significant determinant of the behavioral intention to use mobile learning and mobile services (e.g., Huang and Lin, 2007; Wang and Shih, 2008a; Wang and Li, 2012). It is necessary to make learning activities more enjoyable so as to promote learner's acceptance and use of mobile learning due to a possible sense of pressure during the process of learning. The rationale is that individuals who experience pleasure or enjoyment from using an information system are more likely to intend to use it extensively than those who do not (Venkatesh, 2000). Therefore, perceived enjoyment is included in the study.

The above key variables that might be critical to mobile learning acceptance provide the foundation for developing a theoretical framework that represents implementation of mobile learning systems and services in a university environment. As shown in Fig.3.5, this framework incorporates the perspectives of both educational institutions and learners. "Technical", "social", "organizational", "individual", and "educational" components are served as "upper level of dimensions" since successful implementation of mobile learning involves efforts from those five aspects based on the literature review. The key variables in Fig.3.4 associated with each "upper level of dimension" are served as "sub-dimensions"

and basis of hypothesis formulation and testing. In addition, university support and financial resources are added under facilitating conditions. University support considers management support, technical support, and training provided by educational institutions. Financial resources are concerned with costs associated with mobile learning, such as devices, application purchase.

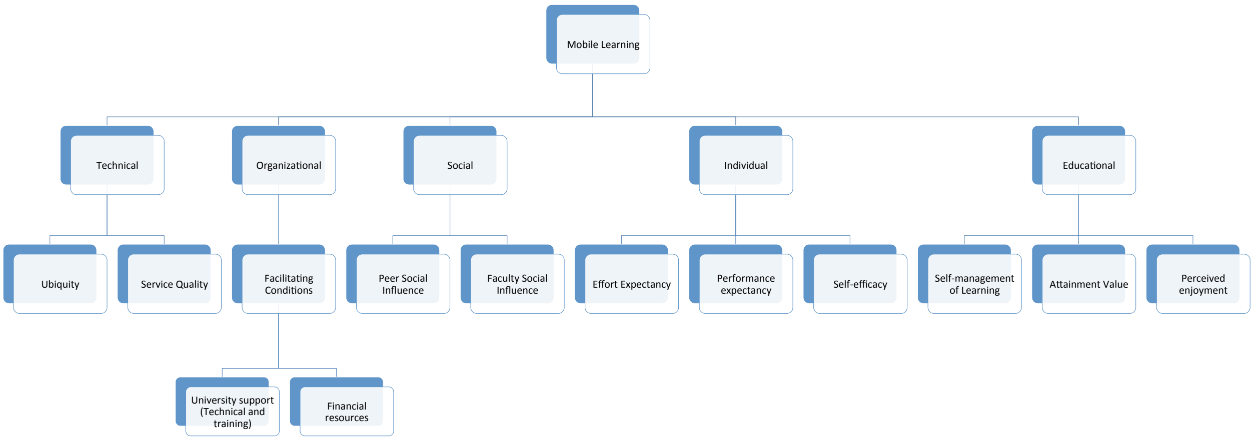

Figure 3.5: Mobile learning components in a university environment

3.6 Research Hypotheses

Based on the research model elaborated in Section 3.5, we have following hypotheses formulated and to be tested in this research, as shown in Fig.3.6.

Hypothesis 1 (H1): Performance expectancy is positively related to behavior intention to use mobile learning.

Hypothesis 2 (H2): Effort expectancy is positively related to behavior intention to use mobile learning.

Hypothesis 3 (H3): Social influence is positively related to behavior intention to use mobile learning.

Hypothesis 4 (H4): Facilitating conditions are positively related to behavior intention to use mobile learning.

Hypothesis 5 (H5): Self-efficacy is positively related to behavior intention to use mobile learning.

Hypothesis 6 (H6): Ubiquity is positively related to behavior intention to use mobile learning.

Hypothesis 7 (H7): Attainment value is positively related to behavior intention to use mobile learning.

Hypothesis 8 (H8): Self-management of learning is positively related to behavior intention to use mobile learning.

Hypothesis 9 (H9): Service quality is positively related to behavior intention to use mobile learning.

Hypothesis 10 (H10): Perceived enjoyment is positively related to behavior intention to use mobile learning.

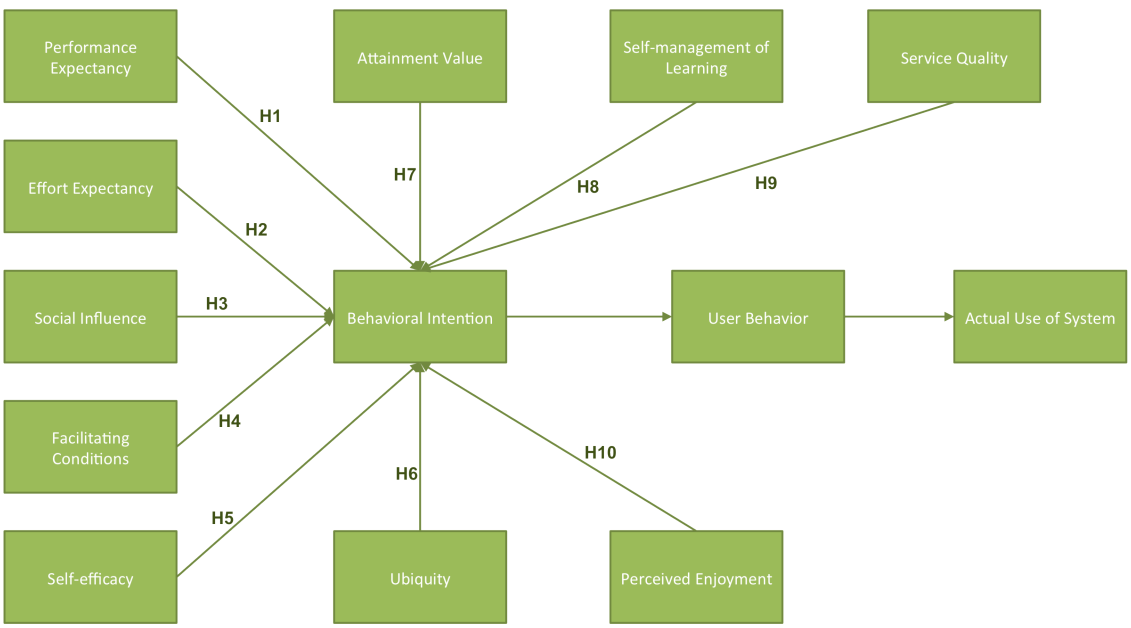

Figure 3.6: Research hypotheses in relation to key variables

In order to test the research hypotheses, the variables stated in Section 3.5 need to be quantified and thus be measurable. Therefore, items measuring these variables are developed

into research questionnaire. The questionnaire used for operationalization and quantification of the research variables are derived from different research areas and modified for the context of mobile learning.

3.7 Summary

The UTAUT and TAM models have been the robust tools for researching acceptance and user perceptions of different technologies and settings with high reliability. They served as underlying theoretical foundations to develop the research model and formulate the research hypotheses in this chapter. The factors possibly influencing mobile learning acceptance were identified through reviewing relevant research and studies. Along with established UTAUT variables, new variables, including self-efficacy, ubiquity, self-management of learning, attainment value, service quality, and perceived enjoyment, were integrated into the research model. As the conclusion of this chapter, ten hypotheses were presented for empirical testing in next chapter.

Chapter 4

Method

4.1 Introduction

This chapter outlines the research design that includes the description of sample population, sampling method, survey instrument, and data collection procedures. The survey instrument is developed for evaluating the research model presented in Chapter 3. The instrument is modified on the basis of previous research and adapted to the mobile learning context. This chapter describes the pilot test for measuring instrument reliability and content and face validities. Other data analysis results and findings and their implications are presented and discussed in Chapter 5.

4.2 Research Design

This research employed a mixed design method. It contained both a quantitative and qualitative component to examine students' acceptance and use of mobile learning. The quantitative component was derived from the survey data collected from the students in College of Engineering in University of Tennessee, Knoxville; the qualitative component was derived from the interviews of the students within the same population. This research used a cross-sectional survey that gathers information at a single point of time to collect quantitative data. Since this research was quantitative in nature, the quantitative methods were applied

to analyze survey data, discover factors impacting students' acceptance of mobile learning and relationships between the factors, and compare similarities and differences across student groups based on gender, age, and prior experience. This research also incorporated qualitative component, therefore, the interview was used to collect students' responses and comments to supplement the results of the survey instrument.

4.3 Sample Population

The sample population in this research consists of 3222 students who were enrolled in College of Engineering in University of Tennessee, Knoxville for spring semester, 2013. The student demographics are reported as below:

1. Gender: 17% female and 83% male;
2. College level: 13% freshman, 14% sophomore, 16% junior, 29% senior, and 28% graduate;
3. Status: 87% full-time students and 13% part-time students.

4.4 Participants

For the quantitative data, the entire sample population was surveyed. Convenience sampling was selected as the sampling method for the qualitative data because the subjects were conveniently accessible and proximate to the researcher. The interview participants were the students who were involved in the course of "Advanced Application System Model and Simulation". They were informed that the interview was voluntary and they could contact the researcher for any questions related to this study or University of Tennessee-Knoxville Institutional Review Board (IRB) for any adverse effects.

4.5 Survey Instrument and Interview Questions

The survey instrument was derived from previous literature and different areas of research. The original survey instrument covered students' demographic information and included fifty-six Likert-scale questions for ten variables described in Section 3.5, and two multiple-choice questions on learning resources and activities. The questions measured students' perceptions of mobile learning with 5-point Likert-scales, ranging from completely disagree to completely agree. Ten interview questions were developed by the faculty form the Department of Theory and Practice in Teacher Education and the researcher in order to collect qualitative data and answer the research questions. The survey instrument and interview questions are presented in Appendix A.1 and A.2.

4.6 Ethical Considerations

Consent was required for this study since it was involved gathering information from students. Consent was essential for participating in the survey and interview. The consent form was developed so that no identifying information was collected with the data. Participants were assured that their responses were anonymous and had no impact on their academic performance. For the survey, the consent form was sent via email and submission of the online survey implied the consent. For the interview, the consent form was given to each participant individually and personally by the researcher. If they were willing to participate in the interview, they could sign their name on the form. Data collection procedures for both pilot test and final survey deployment were approved by University of Tennessee-Knoxville Institutional Review Board (IRB) (see Appendix B).

4.7 Pilot Test

A pilot test was administered to the students whose major is Industrial and Systems Engineering. The purpose of this pilot test was to test face and content validities of the

instrument and initially evaluate its reliability. The below presents the process and results of the pilot test. The statistical outputs were obtained by IBM SPSS21.

4.7.1 Participants

The participants involved in this pilot test were 14 graduate students who enrolled the course of "Advanced Application System Model and Simulation" (IE526). Each student voluntarily signed up to participate in this research project at the beginning of fall semester 2012. Upon signing up the project, each student had an option to have a free iPad2 as a mobile learning tool throughout the semester. 12 students chose to use the iPads provided to them, and 2 students chose to use their own iPads. In addition, each iPad provided to the students was installed with pre-purchased educational apps as learning aids, such as note taking, organization, referencing, simulation and data collection.

4.7.2 Data Collection

Data collection instrument was the questionnaire presented in Appendix A.1. To avoid confusion, the names of each variable described in research model were not included in the questionnaire. During the data collection process, the researcher introduced the purpose of this study and the definition of mobile learning at the beginning of the semester; then the students completed the survey online toward the end of the semester.

4.7.3 Measurement

The survey instrument was validated in terms of reliability and validity. Reliability is the degree to which a test consistently measures whatever it is measuring (Hayes, 1998). Initial internal consistency reliability was assessed on the data collected in the pilot test using reliability coefficient of Cronbach's alpha (Lattin et al., 2003). It is calculated as follows:

$$\alpha = \frac{k\bar{r}}{[1 + (k-1)\bar{r}]}, \tag{4.1}$$

where k is the number of items used in the scale and $\bar{r}$ is the average inter-item correlation among the k items.

A high reliability coefficient indicates a highly reliable instrument. Minimum acceptable reliability coefficients range from 0.70 to 0.80 (DeVellis, 1991). The original survey instrument contained fifty-six Likert-scale questions in regard to the key variables in the research model. Initial reliability analysis on the pilot test data revealed that Cronbach's alpha for ubiquity, self-efficacy, and perceived enjoyment were far below 0.70. After further inspection of the items and outputs, it was discovered that the scale reliability would significantly improve if item Ubi4 in ubiquity scale, item SE4 in self-efficacy scale, and item PEn3 and PEn4 in perceived enjoyment scale were deleted. Thus, the researcher decided to delete these four items. The results of reliability analysis along with scale statistics of final survey instrument are presented in Table 4.1. The Cronbach's alpha for each scale is within the acceptable range.

Table 4.1: Results of reliability analysis on final survey instrument

Scale	Mean	Std Deviation	N	Cronbach's alpha
Performance expectancy	20.29	2.555	5	0.798
Effort expectancy	21.64	2.023	5	0.755
Social influence	16.14	2.070	4	0.739
Facilitating conditions	15.86	2.179	4	0.720
Self-efficacy	12.36	2.898	4	0.715
Ubiquity	21.64	2.170	5	0.700
Attainment value	11.86	1.406	3	0.718
Self-management of learning	18.86	2.538	5	0.708
Service quality	31.50	3.132	7	0.885
Perceived enjoyment	15.57	2.243	4	0.716
Behavior intention	25.50	3.414	6	0.920

Validity is the degree to which a test measures what it is supposed to measure and permits the appropriate interpretation of scores (Gay et al., 2006). In the pilot test, the researcher examined face and content validities. Face validity is referred as the degree to

which a test appears to measure what it claims to measure, and content validity is defined as the degree to which a test measures an intended content area (Gay et al., 2006). To ensure face and content validities of the survey instrument, faculties from the Department of Industrial and Systems Engineering and Department of Theory and Practice in Teacher Education examined the instrument and provided comments and feedback. This was an iterative process that resulted in rewording many of the questions for clarity, comfort level, and appropriateness and improving the layout of the questionnaire. The instrument was modified according to the feedback. This pilot test revealed that questions on the survey did not cause problems for students in terms of language and clarity.

4.8 Final Survey Instrument

After pilot testing and examining face and content validities and reliability, the original instrument was finalized to fifty-two items for administering to the sample population. Throughout the process of instrument development and testing, the emphasis was on the proper instrument design for subsequent statistical analysis. The final survey instrument is presented in Appendix A.1.

4.9 Data Collection Procedures

The first portion of data collection consisted of collecting quantitative data from the self-reported survey instrument. The final survey instrument was deployed and administered online. To avoid confusion and bias, the names of each key variable in the research model were omitted in the online survey. The email containing the consent form and URL link to the online survey was sent to the students who were enrolled in College of Engineering for spring semester 2013. The link to the online survey was provided by SPSS web survey tool. The participation in the survey was optional. Each participant would have a chance to win a reward after the submission of the survey. In order to increase the response rate, the researcher sent two follow-up emails. The first one was sent seven day after the initial

survey, and the second one was sent five days after first follow-up. The second portion of data collection consisted of collecting qualitative data from the interviews. The participants were interviewed one-on-one after closing the survey. Five students were interviewed.

4.10 Summary

In this research, quantitative and qualitative methods were both employed to investigate factors impacting students' acceptance of mobile learning. Quantitative data were collected by online survey; quantitative data were obtained by students' interviews. In order to validate the survey instrument, the researcher examined the internal consistency reliability, face validity, and content validity in the pilot test phase. After inspecting the outputs, the survey instrument was finalized and resulted in that the reliability coefficients were 0.70 or greater for each scale, which satisfied the reliability requirement. Content validity and face validity ensured the clarity and appropriateness of the instrument. Pilot test resulted in no confusion or misunderstanding. The final survey instrument was then deployed and administered online to the sample population. The quantitative and qualitative findings from data analysis are presented and interpreted in Chapter 5.

Chapter 5

Research Findings

5.1 Introduction

Data analysis and results are presented in this chapter. The data analysis uses descriptive statistics, frequencies, factor analysis, correlation analysis and linear regression for determining relationships between variables, and t-tests and ANOVA for group comparisons. The data were analyzed using the IBM SPSS21. The chapter commences with descriptive statistics, proceeds with factor analysis and relational analysis in order to answer research questions and test research hypotheses, and concludes with discussion and implication on relevant research findings.

5.2 Sample Descriptive Statistics

The sample population in this research were 3222 students enrolled in College of Engineering in spring semester 2013. The demographic data were obtained from total of 377 respondents. To avoid missing data, each question in the survey was required a response. Table 5.1, 5.2, and 5.3 present the frequencies among the respondents with regard to their gender, college level, years of using mobile devices, prior mobile learning experience, current mobile device ownership, and planned purchase of mobile devices. Device ownership and experience would likely influence students' behavioral intention and their acceptance of mobile learning, and

therefore they were included in the survey. Table 5.4 includes the frequencies of learning resources that students would like to access via mobile devices; Table 5.5 includes the frequencies of learning activities that students would like to perform on mobile devices. The frequency column summarizes the number of total cases. The percent column displays this frequency in percentage form for all cases, including cases that may be missing. The valid percent column is the proportion of scores only for those cases that are valid. Since there were no missing data in this research, values in percent column equal to the ones in valid percent column.

As in Table 5.1, 28.9% of students were female and 71.1% were male. The respondents' college level was reported as follows: 12.2% freshman, 16.2% sophomore, 18.0% junior, 28.7% senior, and 24.9% graduate. A majority of students (80.9%) reported having used mobile devices for education or learning purpose before, and 97.6% reported having more than one year of experience with using mobile devices, which is indicative of prevalence of using mobile devices among students.

Device ownership statistics in Table 5.2 reveal that 81.7% of respondents owned smartphones; 53.8% owned MP3 players or similar devices; 41.7% owned tablets; 2.1% owned PDAs; only 1.6 % didn't own mobile devices indicated in the survey. As in Table 5.3, the percentage of students who intended to purchase a smartphone in future was 31.0%, compared to 29.7% for a tablet, 5.8% for a MP3 player or similar devices, and 0.3% for a PDA. Nearly half of students (49.3%) responded planning to purchase mobile devices in future. The low number of students who planned to purchase a MP3 player or similar device is most likely indicative of the high level of ownership of such device. The numbers revealed that tables and smartphone were the devices that students most wanted to purchase. This may indicate that students are most likely requiring the functionalities offered by this device.

Of all respondents, 93.9% of students chose to access lecture PowerPoint slides using mobile devices, 92.0% for Blackboard, 81.4% for videos, and 69.2% for recordings, as shown in Table 5.4. This may indicate that students are most likely requiring more the course related materials that can be accessed by mobile devices and their preferences of digital over paper-based materials. More than half of students (69.0%) chose educational apps, most

Table 5.1: Frequencies table of demographics

Gender		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	109	28.9	28.9	100.0
	Male	268	71.1	71.1	71.1
Total	377				
Age		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 18	1	0.3	0.3	0.3
	18-22	229	60.7	60.7	61
	23-26	75	19.9	19.9	80.9
	over 26	72	19.1	19.1	100.0
Total	377				
College Level		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Freshman	46	12.2	12.2	12.2
	Sophomore	61	16.2	16.2	28.4
	Junior	68	18.0	18.0	46.4
	Senior	108	28.7	28.7	75.1
	Graduate	94	24.9	24.9	100.0
Total	377				
Mobile Learning Experience		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	305	80.9	80.9	80.9
	No	72	19.1	19.1	100.0
Total	377				
Years of Using Mobile Devices		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	≤ 1	37	9.8	9.8	9.8
	2-3	102	27.1	27.1	36.9
	4-6	119	31.6	31.6	68.4
	> 6	110	29.2	29.2	97.6
	N/A	9	2.4	2.4	100.0
Total	377				

likely indicating that their use as learning aids and referencing tools. In terms of learning activities (see Table 5.5), a large number of students (86.7%) reported sharing information via

Table 5.2: Frequencies table of mobile device ownership

Smartphone		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	308	81.7	81.7	81.7
	No	69	18.3	18.3	100.0
Total	377				
PDA		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	2.1	2.1	2.1
	No	369	97.9	97.9	100.0
Total	377				
Tablet		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	157	41.7	41.7	41.7
	No	220	58.3	58.3	100.0
Total	377				
MP3 or Similar Device		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	203	53.8	53.8	53.8
	No	174	46.2	46.2	100.0
Total	377				
No Device owned		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	1.6	1.6	1.6
	No	371	98.4	98.4	100.0
Total	377				

mobile devices. This is reasonable since those devices, especially smartphones, were originally invented for communicating and exchanging information. With availability of mobile social networking (e.g., apps for Facebook and Twitter), such information sharing has become more popular among students. 85.7% of students chose checking information online, followed by 75.1% for reading and keeping track of assignments, 70.0% for accessing/delivering online learning materials/contents, 69.2% for undertaking simple multiple choice quizzes, and 69.0% for keeping in touch with course professor. Only 3.4% reported not using mobile devices for any learning activities.

Table 5.3: Frequencies table of mobile device planned to purchase

Smartphone		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	117	31.0	31.0	31.0
	No	260	69.0	69.0	100.0
Total	377				
PDA		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	0.3	0.3	0.3
	No	376	99.7	99.7	100.0
Total	377				
Tablet		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	112	29.7	29.7	29.7
	No	265	70.3	70.3	100.0
Total	377				
MP3 or Similar Device		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	22	5.8	5.8	5.8
	No	355	94.2	94.2	100.0
Total	377				
Plan to Purchase		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	191	49.3	50.7	50.7
	No	186	50.7	50.7	100.0
Total	377				

Appendix C contains descriptive statistics for all items. Frequency tables are presented in Appendix C.1; mean, minimum and maximum values, and standard deviations are summarized in Appendix C.2. The data were analyzed and inspected before proceeding to the next phase of statistical analysis, which includes factor analysis, hypothesis testing, and group analysis.

The data indicate that students mainly felt positive about the use of mobile learning. Fig.5.1 shows the average score values for each scale. Performance expectancy (PE) item means range from 3.45 to 4.02; effort expectancy (EE) item means range from 4.07 to 4.24;

Table 5.4: Frequencies table of learning resources

Resource	Frequency	Percent	Valid Percent
Lecture PPT slides	354	93.9	93.9
Blackboard	347	92.0	92.0
Videos (e.g., course related, recordings of lectures, school information)	307	81.4	81.4
Audio recordings (e.g., recordings of lectures)	261	69.2	69.2
Educational Apps	260	69.0	69.0
Hyperlinks to course related reference materials	243	64.5	64.5
Flashcards and other interactive educational games	237	62.9	62.9
Others	48	12.7	12.7

self-efficacy (SE) item means range from 3.63 to 4; perceived enjoyment (PEn) item means range from 3.63 to 3.70; social influence (SI) item means range from 3.47 to 4.03; facilitating conditions (FC) item means range from 3.58 to 4.00; self-management of learning (SML) item means range from 3.29 to 4.11; ubiquity (Ubi) item means range from 3.74 to 4.40; attainment value (AV) item means range from 3.1 to 3.5; service quality (SQ) item means range from 3.94 to 4.63; behavior intention (BI) item means range from 3.66 to 4.07. Frequency tables in Appendix C.1 show a mainly positive view of most items, except that two items in attainment value scale were scored most highly on "neither agree nor disagree" but with a relatively high positive cumulative percentage.

5.3 Normality and Outliers

Normality is an assumption for many multivariate techniques. Factor analysis depends on the correlation matrix between the variables and the factors. Thus, outliers and normality were examined and included in initial data inspection. Kurtosis and skewness are the two main indicators of univariate normality which refer to the shape of the distribution and is used with both interval and ratio scale data. Exactly normal distributions have zero values

Table 5.5: Frequencies table of learning activities

Activity	Frequency	Percent	Valid Percent
Share information (email, SMS, et.al)	327	86.7	86.7
Check information online	323	85.7	85.7
Read and keep track of assignment	283	75.1	75.1
Access/deliver online learning materials/contents	264	70.0	70.0
Undertake simple multiple choice quizzes	261	69.2	69.2
Keep in touch with course professor	260	69.0	69.0
Coordinate tasks for a course project	254	67.4	67.4
Keep in touch with classmates	247	65.5	65.5
Receive administrative messages from the university	234	62.1	62.1
Collect data	229	60.7	60.7
Receive guidance on learning activities from course professor	213	56.5	56.5
Supplement print based learning materials/content	211	56.0	56.0
Report on assignments	192	50.9	50.9
Take notes	185	49.1	49.1
Discuss topics covered in a given course	181	48.0	48.0
Write assignment	106	28.1	28.1
Others	28	7.4	7.4
Don't use mobile devices for learning activities at all	13	3.4	3.4

for both kurtosis and skewness. A positive skewness indicates a greater number of smaller values, while a positive value for kurtosis indicates a distribution that is more peaked than normal. Negative values for skewness indicate a greater number of larger values, and for kurtosis, a flatter distribution.

Descriptive statistics of all items, including skewness and kurtosis, are presented in Appendix C.2. Skewness is consistently negative, indicating a higher average number of agreements across all variables. This is also indicated by the variable means showing that most of the respondents were agreeable on survey items or had average satisfaction with mobile learning. Most values of skewness and kurtosis fall within the recommended range of ± 1. A few items fall outside that range but within the range of ± 2. This is considered

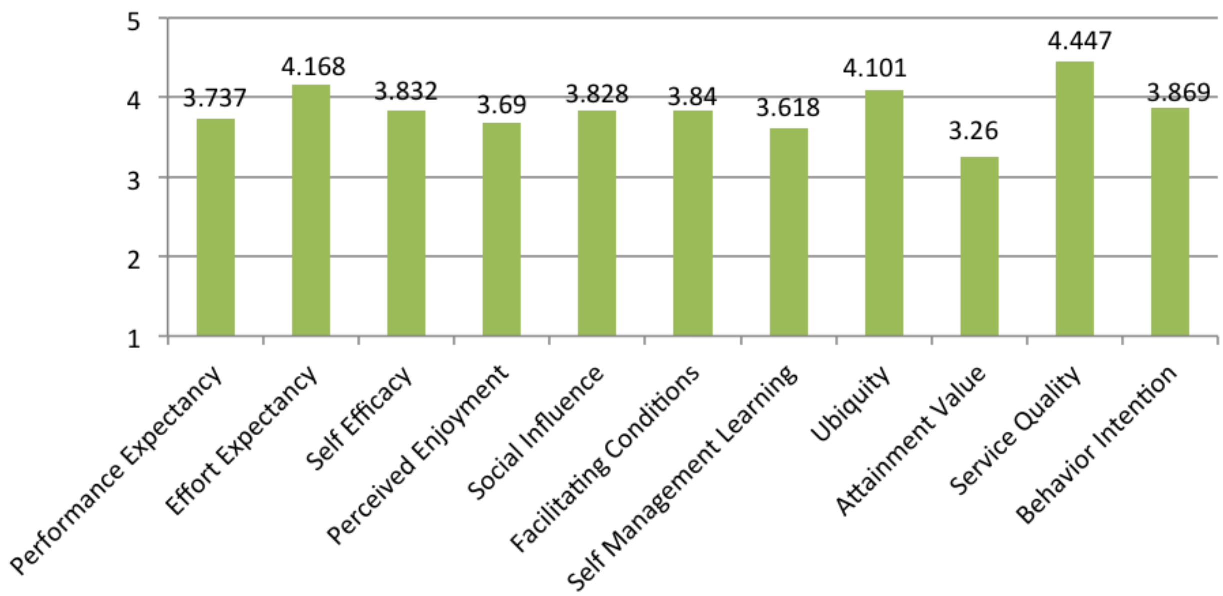

Figure 5.1: Average score for each scale

acceptable according to George and Mallery (2007). Hair et al. (1998) suggested using the skewness value to compare with a critical value. The critical value is based on the significance level desired. For a significance level of .05 the critical value is ±1.96. Additionally, the central limit theorem states that even if a population distribution is strongly non-normal, its sampling distribution of means will be approximately normal for large sample sizes (over 40). Hair et al. (1998) expressed a similar view regarding the effect of large sample sizes on normality: large sample sizes tend to diminish violations of normality. Thus the data were accepted for normality.

To detect outliers, the data were converted to standardized scores (Z-scores). Inspection of Z-scores enables identification of outliers; cases with Z-scores greater than +3 and less than -3 are considered outliers (Kutner et al., 2004). The outliers were examined and identified by such method. Approximately 7.96% of cases had multiple outliers. However, the data were considered acceptable because of very small percent of cases with multiple outliers. Unless the outliers are truly exceptional observations or are erroneous, eliminating outliers is cautioned because the outliers might still be representative of the population (Hair et al., 1998). Thus, those cases were not deleted.

5.4 Instrument Reliability

Cronbach's alphas were examined to assess the level of internal consistency reliability of the scales. Cronbach's alpha is based upon the average correlation among the items in a scale. The reliability coefficients in Table 5.6 reveal that the following scales demonstrated sufficient levels (0.70 or greater) of internal consistency reliability: performance expectancy, effort expectancy, social influence, perceived playfulness, attainment value, self-management of learning, service quality, and behavioral intention to use mobile learning. Cronbach's alphas for facilitating conditions and self-efficacy are relatively low. For the latter, this alpha is poor. However, they were revised as the analysis proceeds to the discussion of exploratory factory analysis in the next.

Table 5.6: Internal consistency reliability of survey instrument

Scale	Scale Mean	Std Deviation	N of Item	Item Mean	Cronbach's alpha
Attainment value	9.78	2.811	3	3.26	0.848
Behavior intention	23.21	4.877	6	3.869	0.937
Effort expectancy	20.84	3.364	5	4.168	0.882
Facilitating conditions	15.36	2.723	4	3.84	0.564
Perceived enjoyment	14.75	3.419	4	3.69	0.889
Performance expectancy	18.69	4.120	5	3.737	0.912
Self-efficacy	15.33	2.411	4	3.832	0.647
Self-management of learning	18.09	3.714	5	3.618	0.813
Service quality	31.13	3.789	7	4.447	0.882
Social influence	15.31	2.901	4	3.828	0.847
Ubiquity	20.50	3.107	5	4.101	0.783

5.5 Exploratory Factor Analysis

To assess dimensions from the survey items, exploratory factor analysis (EFA) was performed on those items with regard to the variables that are antecedent to the actual usage of mobile learning.

In EFA, the observed variables are a linear combination of the underlying and unique factors that account for common variance in a data set; the amount of variance explained is the trace (sum of the diagonals) of the decomposed adjusted correlation matrix; eigenvalues indicate the amount of variance explained by each factor; eigenvectors are the weights that could be used to calculate factor scores (Lattin et al., 2003). Commonly, factor scores are calculated with a mean or sum of measured variables that load on a factor (Lattin et al., 2003). Statistically, the EFA Model is

$$Y = X\beta + E, \tag{5.1}$$

where Y is a matrix of measured variables;

X is a matrix of common factor;

β is a matrix of weights (factor loadings);

E is a matrix of unique factors, error variation.

In this research, the principal components method with Varimax rotation was used in EFA in order to assess if the dimensions from the survey items were in line with the research model (as shown in Fig.3.4). Principal components is a factor extraction method used to form uncorrelated linear combinations of the observed variables. It is variance-based, and the first component has maximum variance. Successive components explain progressively smaller portions of the variance and are all uncorrelated with each other. Principal components method was used to obtain the initial factor solution. In order to determine appropriateness of proceeding with exploratory factor analysis, the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test of sphericity were performed. KMO tests whether the partial correlations among variables are small and thus are likely to factor well; the KMO value should be higher than 0.50 while a value of 0.90 or higher is considered excellent for a factor analysis (Lattin et al., 2003). Bartlett's test of sphericity is a measure of multivariate normality and tests whether the correlation matrix is an identity matrix indicating that the factor model is inappropriate; the test needs to be significant in order to proceed with factor analysis (Lattin

et al., 2003). In order to identify the factor structure, the following criteria were applied to remove items (Hair et al., 1998):

- Items that do not load with any other item will be removed. Moreover items will be removed if they have loadings less than 0.50.
- Items that load on more than one factor will be removed due to violation of the simple structure factor solutions (only one loading on any factor for each variable). Double loading occurs when the factor score is greater than 0.50 on more than one factor. Additionally, an item will be removed if it loads on a factor where theoretically it seems unreasonable for that item to be associated with other items in the factor.
- Items with a measure of sampling adequacy (MSA) less than 0.50 in the anti-image matrix will be removed.

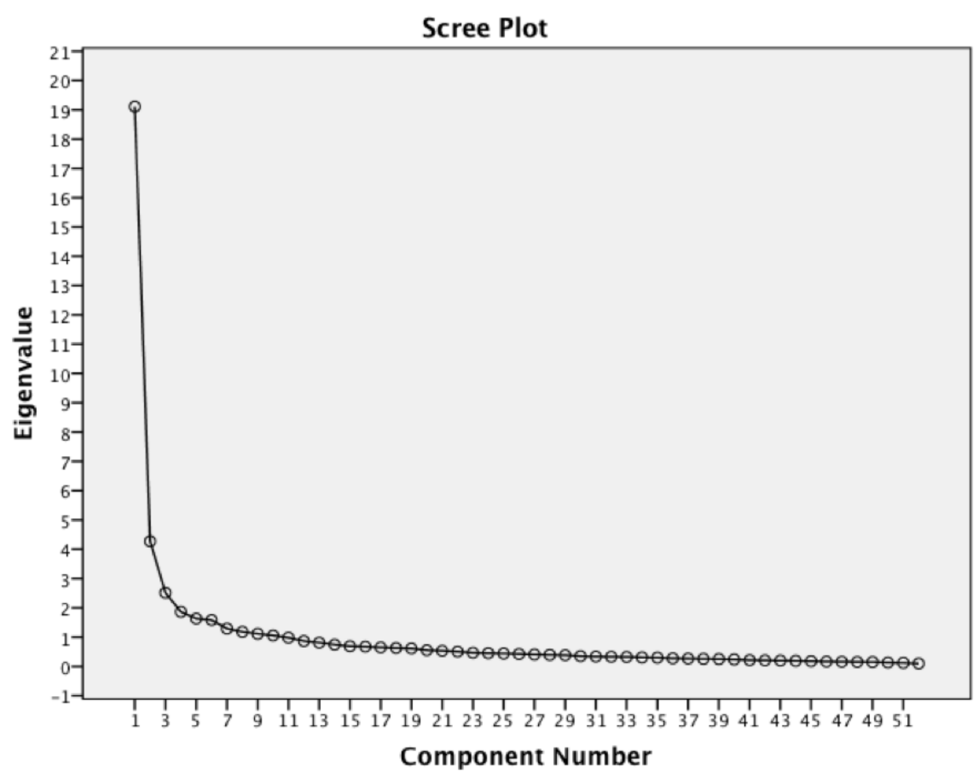

Figure 5.2: Scree Plot

For choosing the number of factors, the literature has multiple methods, the most recommended of which is to extract factors with an eigenvalue of larger than one. The scree plot, which is a plot of the eigenvalues, is another method to inspect the number of factors. This study used the criterion of eigenvalue being above one in addition to the scree plot. The number of factors based on the eigenvalues is eleven, as shown in Table D.57. Scree plot in Fig.5.2 illustrates final factor solution. The value of KMO in Table 5.7 is 0.944 and Bartlett's test of Sphericity is significant, indicating that the data were appropriate for factor analysis. Table D.59 contains the final component (factor) matrix. It is a matrix of loadings or correlations between the variables and factors. The component matrix was rotated using Varimax rotation method in order to align the factors and present the factor structure. The factor matrix filtered out the items listed in Table 5.8 since they did not meet the loading criteria stated previously after inspecting initial factor solution. Reliability analysis was performed on those scales whose items were removed in order to revise the internal consistency reliabilities, the results of which are presented in Table 5.9.

Table 5.7: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.944
Bartlett's Test of Sphericity	Approx. Chi-Square	11166.936
	df	780
	Sig.	0.000

The final factor solution in Table D.59 took into account of removing the items in Table 5.8. All items loaded on the appropriate factor with loadings of above 0.5. The cumulative variance explained by these factors is 76.56% (see Table D.57). This value explains how well a particular factor solution accounts for what all the variables together represent, in other words, the amount of variance represented by the information in the factor matrix (Lattin et al., 2003). The total variance explained by these factors is high, indicating that the variables are in fact highly related to each other. The factor analysis resulted in eleven factors, matching the hypothetical research model dimensions. The

Table 5.8: Removed items

Scale	Removed Item	Removing Criteria	Explanation & Indication
Attainment value	AV1	Factor loading less than 0.5	This item is more related to engagement instead of achievement and self-importance.
Effort expectancy	EE5	Factor loading less than 0.5	This item is more related to ubiquitous access instead of ease of use.
Facilitation conditions	FC3, FC4	MSA less than 0.5	This may indicate that students are less concerned with personal finance due to decreasing costs of mobile devices and applications.
Perceived enjoyment	PEn1	Factor loading less than 0.5	This item more depends on personal interest in learning.
Self-efficacy	SE3, SE5	Factor loading less than 0.5	These two items may not be applicable due to students' familiarity with mobile deceives, which is revealed in demographic data.
Self-management of learning	SML1	Loading on wrong factor	This item is related to personal learning habit instead of mobile learning.
Service quality	SQ6	Factor loading less than 0.5	This item stresses on service availability instead of quality of mobile learning content.
Ubiquity	Ubi5, Ubi6	Factor loading less than 0.5	These two items stress on interaction and tracking learning performance instead of ubiquitous access.

reliabilities of these dimensions were in the sufficient range (0.7 or greater) respectively. Additionally, the items that intended to measure the same dimension exhibited distinctly higher factor loadings on a single component than on other components, suggesting adequate convergent and discriminant validity. The revised reliability analysis suggested adequacy of the measurements used in the study.

Table 5.9: Revised internal consistency reliability

Scale	Scale Mean	Std Deviation	N of Item	Item Mean	Cronbach's alpha
Attainment value	6.38	2.082	2	3.19	0.921
Effort expectancy	16.66	2.737	4	4.165	0.878
Facilitating conditions	7.85	1.667	2	3.925	0.842
Perceived enjoyment	11.07	2.591	3	3.69	0.861
Self-efficacy	7.329	1.629	2	3.665	0.700
Self-management of learning	13.98	3.490	4	3.495	0.875
Service quality	27.19	3.339	6	4.532	0.904
Ubiquity	12.56	1.998	3	4.52	0.770

5.6 Validity Analysis

Validity is, as previously stated, the degree to which a test measures what it is supposed to measure and permits the appropriate interpretation of scores (Gay et al., 2006). It is a matter of degree to which the scale measures what it is designed to measure (Hayes, 1998). Content and face validities of the instrument were examined and discussed in the pilot test phase in Chapter 4. The further investigation of validity, including convergent and descrimimant validities, is addressed in the following.

5.6.1 Convergent Validity

Convergent validity assesses whether items under individual scale are correlated; it can be evidenced by relatively high correlations between items under same scale (Campbell and Fiske, 1959). Therefore, convergent validity was investigated through correlations between the individual scale items. As presented in Appendix E.1, all correlations of scale items were significant at the 0.01 level (2-tailed). Attainment value scale item correlation is 0.835. Facilitating conditions scale item correlation is 0.728. Self-efficacy scale item correlation is 0.535. Behavior intention scale item correlations range from 0.644 to 0.764. Effort efficacy scale item correlations range from 0.590 to 0.712. Perceived enjoyment scale item correlations range from 0.600 to 0.756. Performance expectancy scale item correlations range from 0.621 to 0.750. Self-management of learning scale item correlations range from 0.528 to 0.690.

Service quality scale item correlations range from 0.537 to 0.748. Social influence scale item correlations range from 0.510 to 0.689. Ubiquity scale item correlations range from 0.528 to 0.591. Campbell and Fiske (1959) suggested that it should consider dropping any scale items with correlation less than 0.3. Results in Appendix E.1 demonstrate convergent validity based on this criterion since no values are below 0.3. Convergent validity is also demonstrated by the factor loadings. Component factor loadings are significant and above 0.50, which demonstrates that the scale correlates with items with which it should correlate and thus shows convergent validity.

5.6.2 Discriminant Validity

Discriminant validity tests whether two scales are indeed uncorrelated; it can be calculated as below (Campbell and Fiske, 1959):

$$\frac{r_{xy}}{\sqrt{r_{xx}r_{yy}}}, \tag{5.2}$$

where r_{xy} is the correlation between x and y, r_{xx} and r_{yy} are reliability of x and y respectively.

A result less than 0.85 indicates that discriminant validity likely exists between the two scales; otherwise it indicates that the two scales likely measures the same concept (Campbell and Fiske, 1959). The values for discriminant validity analysis were evaluated based on this criterion. As presented in Appendix E.2, all off-diagonal values are less than 0.85, which demonstrates discriminant validity.

5.7 Research Hypotheses Evaluation

Exploratory factor analysis was used to evaluate the research model. Eleven factors were discovered through principal components method. As a result, one item was receptively removed from scale of attainment value, effort expectancy, perceived enjoyment, self-management of learning, and service quality; two items were respectively removed from scale of facilitating conditions, self-efficacy, and ubiquity. As the next step of model evaluation,

ten hypotheses were tested by correlation and regression analysis in order to investigate the relationships hypothesized in the research model.

5.7.1 Hypotheses Testing - Correlation

This research first used Pearson product-moment correlation coefficient to examine correlations between the variables in the hypothesized relationship. A Pearson product-moment correlation coefficient describes the relationship between two continuous variables; it is appropriate for interval and ratio scale variables and is the most common measure of linear relationship (Kutner et al., 2004). When a hypothesis indicates that a significant positive relationship exists between two variables, the correlation found between the two variables is significant.

In this section, ten hypotheses were tested in order to investigate relationships between behavior intention (BI) and its antecedents: performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), social influence (SI), attainment value (AV), self-efficacy (SE), self-management of learning (SML), ubiquity (Ubi), service quality (SQ), and perceived enjoyment (PEn). Means of the items within the same scale were calculated, and correlation analysis was conducted on these values. All hypotheses demonstrated a positive relationship between the factors at a significance of 0.01, the results of which are presented in the next.

Performance Expectancy Hypothesis

The first hypothesis stated that performance expectancy (PE) is positively related to behavior intention (BI) to use mobile learning. Table 5.10 indicates that the correlation coefficient between the two variables is 0.763, which suggests that a positive relationship exists. Therefore, hypothesis one (H1) is supported.

Effort Expectancy Hypothesis

The second hypothesis stated that effort expectancy (EE) is positively related to behavior intention (BI) to use mobile learning. Table 5.11 indicates that the correlation coefficient

Table 5.10: Correlation testing for Hypothesis 1

		PE	BI
PE	Pearson Correlation	1	.763**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.763**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

between the two variables is 0.553, which suggests that a positive relationship exists. Therefore, hypothesis two (H2) is supported.

Table 5.11: Correlation testing for Hypothesis 2

		EE	BI
EE	Pearson Correlation	1	.553**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.553**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Social Influence Hypothesis

The third hypothesis stated that social influence (SI) is positively related to behavior intention (BI) to use mobile learning. Table 5.12 indicates that the correlation coefficient between the two variables is 0.529, which suggests that a positive relationship exists. Therefore, hypothesis three (H3) is supported.

Facilitating Conditions Hypothesis

The fourth hypothesis stated that facilitating conditions (FC) is positively related to behavior intention (BI) to use mobile learning. Table 5.13 indicates that the correlation coefficient

Table 5.12: Correlation testing for Hypothesis 3

		SI	BI
SI	Pearson Correlation	1	.529**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.529**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

between the two variables is 0.459, which suggests that a positive relationship exists although not a strong one. Therefore, hypothesis four (H4) is supported.

Table 5.13: Correlation testing for Hypothesis 4

		FC	BI
FC	Pearson Correlation	1	.459**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.459**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Self-efficacy Hypothesis

The fifth hypothesis stated that self-efficacy (SE) is positively related to behavior intention (BI) to use mobile learning. Table 5.14 indicates that the correlation coefficient between the two variables is 0.317, which suggests that a significant positive relationship exists, although not a strong one. Therefore, hypothesis five (H5) is supported.

Ubiquity Hypothesis

The sixth hypothesis stated that ubiquity (Ubi) is positively related to behavior intention (BI) to use mobile learning. Table 5.15 indicates that the correlation coefficient between

Table 5.14: Correlation testing for Hypothesis 5

		SE	BI
SE	Pearson Correlation	1	.317**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.317**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

the two variables is 0.671, which suggests that a positive relationship exists. Therefore, hypothesis six (H6) is supported.

Table 5.15: Correlation testing for Hypothesis 6

		Ubi	BI
Ubi	Pearson Correlation	1	.671**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.671**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Attainment Value Hypothesis

The seventh hypothesis stated that attainment value (AV) is positively related to behavior intention (BI) to use mobile learning. Table 5.16 indicates that the correlation coefficient between the two variables is 0.557, which suggests that a positive relationship exists. Therefore, hypothesis seven (H7) is supported.

Self-Management of Learning Hypothesis

The eighth hypothesis stated that self-management of learning (SML) is positively related to behavior intention (BI) to use mobile learning. Table 5.17 indicates that the correlation

Table 5.16: Correlation testing for Hypothesis 7

		AV	BI
AV	Pearson Correlation	1	.557**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.557**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

coefficient between the two variables is 0.668, which suggests that a positive relationship exists. Therefore, hypothesis eight (H8) is supported.

Table 5.17: Correlation testing for Hypothesis 8

		SML	BI
SML	Pearson Correlation	1	.668**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.668**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Service Quality Hypothesis

The ninth hypothesis stated that service quality of learning (SQ) is positively related to behavior intention (BI) to use mobile learning. Table 5.18 indicates that the correlation coefficient between the two variables is 0.334, which suggests that a positive relationship exists, although a week one. Therefore, hypothesis nine (H9) is supported.

Perceived Enjoyment Hypothesis

The tenth hypothesis stated that perceived enjoyment of learning (PEn) is positively related to behavior intention (BI) to use mobile learning. Table 5.19 indicates that the correlation

Table 5.18: Correlation testing for Hypothesis 9

		SQ	BI
SQ	Pearson Correlation	1	.334**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.334**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

coefficient between the two variables is 0.708, which suggests that a positive relationship exists. Therefore, hypothesis ten (H10) is supported.

Table 5.19: Correlation testing for Hypothesis 10

		PEn	BI
PEn	Pearson Correlation	1	.708**
	Sig. (2-tailed)		0
	N	377	377
BI	Pearson Correlation	.708**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

All the correlation tests were significant, thereby supporting the research hypotheses at this point. Performance expectancy, effort expectancy, ubiquity, attainment value, self-management of learning, social influence, and perceived enjoyment showed strong positive relationships with behavior intention, as compared to facilitating conditions, self-efficacy, and service quality. Fig.5.3 depicts all the correlations between these factors. It presents the relative predictive power for each dimension.

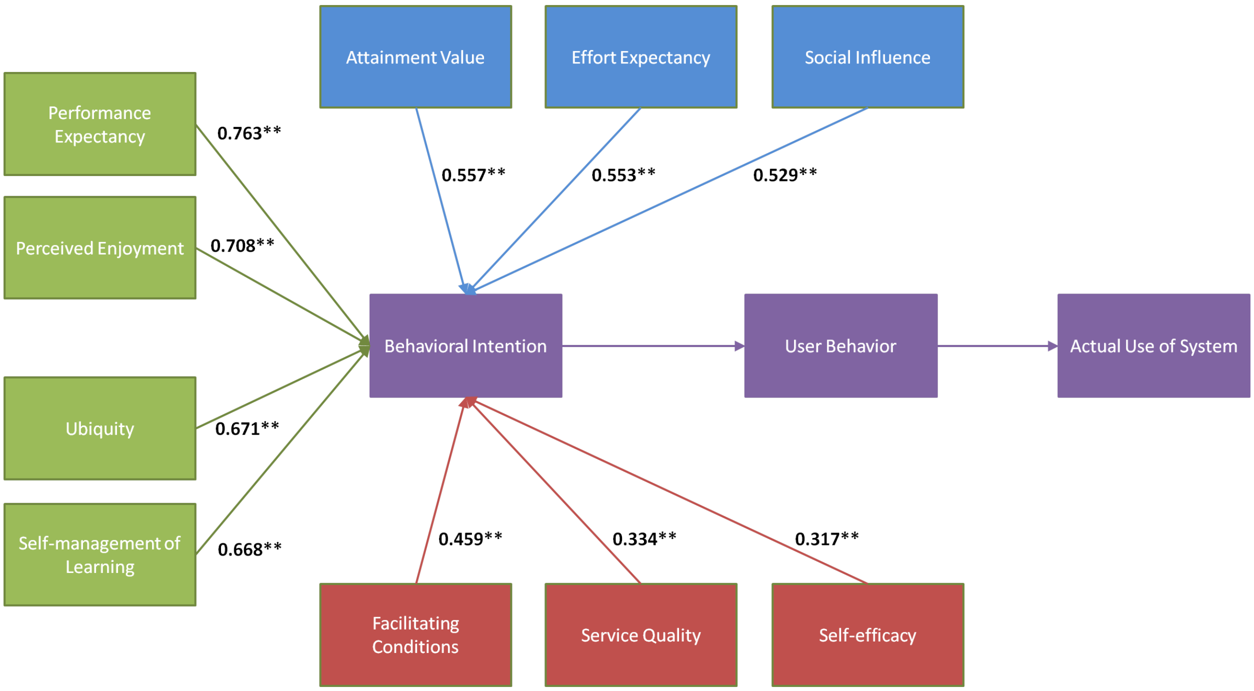

Figure 5.3: Correlational model
***Correlation is significant at the 0.01 level (2-tailed)

5.7.2 Hypotheses Testing - Regression

Multiple regression analysis was performed between the independent variables, including performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), social influence (SI), attainment value (AV), self-efficacy (SE), self-management of learning (SML), ubiquity (Ubi), service quality (SQ), and perceived enjoyment (PEn), and the dependent variable behavior intention (BI) in order to identify the predictors of behavior intention as hypothesized in the research model. Appendix F.1 contains the results of regression analysis.

The coefficient of determination R^2 measures the proportion of the variance of the dependent variable about its mean that is explained by the independent or predictor variables (Kutner et al., 2004). The higher the value of R^2, the greater the explanatory power of the regression model. By the regression results, R^2 value for the dependent variable behavior intention (BI) is 0.708, meaning that 70.8% of the variance in behavior intention is explained by this regression model. This value is considered high and thus the power of the regression

model is good. The model is statistically significant at F=88.812 (p <0.001). However, it has non-significant regression coefficients. The values of the regression coefficients and their significance determine the variables that are included in the model. As shown in Table F.75, regression coefficients of effort expectancy, self-efficacy, social influence, and facilitating conditions are not statistically significant, thereby rejecting H2, H3, H4 and H5. This indicates that the intention to use mobile learning does not increase with increasing or decreasing levels of these factors. The regression analysis supports the following hypotheses:

- Hypothesis 1 (H1): Performance expectancy is positively related to behavior intention to use mobile learning (β=0.380, p=0.000).
- Hypothesis 6 (H6): Ubiquity is positively related to behavior intention to use mobile learning (β=0.151, p=0.001).
- Hypothesis 7 (H7): Attainment value is positively related to behavior intention to use mobile learning (β=0.101, p=0.008).
- Hypothesis 8 (H8): Self-management of learning is positively related to behavior intention to use mobile learning (β=0.109, p=0.015).
- Hypothesis 9 (H9): Service quality is positively related to behavior intention to use mobile learning (β=0.112, p=0.001).
- Hypothesis 10 (H10): Perceived enjoyment is positively related to behavior intention to use mobile learning (β=0.190, p=0.000).

In sum, the regression results reject H2, H3, H4, and H5 and support H1, H6, H7, H8, H9, H10. This indicates that the intention to use mobile learning would not increase with increasing or decreasing levels of facilitating conditions, social influence, effort expectancy, and self-efficacy but would increase with increasing levels of performance expectancy, ubiquity, attainment value, self-management of learning, service quality, and perceived enjoyment.

Tests of regression analysis assumptions (see Appendix F.2 to Appendix F.5), including normality of the residuals, constant variance of the residuals, multicollinearity, linearity between dependent and independent variables, independence of the residuals, and outliers, were also examined in this research:

- Normality of the residuals was examined by visual inspection of the histogram and the normal probability plot of the residuals as shown in Appendix F.2. The histogram in Fig.F.6 is bell-shaped and resembles the normal distribution; the normality plot in Fig.F.7 fall approximately on a straight line. Thus, the normality of the residuals assumption was not violated.

- Constant variance of the residuals was examined by inspecting a plot of the standardized residuals vs. unstandardized predicted values, as shown in Fig. F.8. The plot presents no patterns, and therefore the residuals have constant variance.

- Multicollinearity was be examined by tolerance values and variance inflation factors (VIF). Tolerance is the amount of variability of the independent variable not explained by other independent variables; VIF is the inverse of tolerance (Kutner et al., 2004). Very small tolerance values or large VIF values indicate high collinearity (Kutner et al., 2004). A common cutoff threshold value for tolerance is 0.10 and for VIF is 10. This criterion was applied to the research. The values of tolerance and VIF are included in Table F.75. They are all above 0.1 for tolerance and below 10 for VIF, and therefore multicollinearity assumption was not violated.

- Linearity between dependent and independent variables was examined by inspecting partial regression plots of each predictor in the regression model. No patterns exist in partial regression plots in Appendix F.5, and therefore this assumption was not violated.

- Independence of the residuals was examined by Durbin-Watson statistic, which is calculated as $\frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=2}^{2} e_i^2}$, where $e_i = y_i - \hat{y}_i$ and y_i and $\hat{y}_i$ are, respectively, the observed and predicted values of the dependent variable for individual i. The value of

the Durbin-Watson statistic ranges from zero to four. As a general rule of thumb, the Durbin-Watson statistic is approximately two if residuals are uncorrelated. A value close to zero indicates strong positive correlation, while a value of 4 indicates strong negative correlation. The Durbin-Watson statistic for this regression model is 2.035, indicating no violation in this assumption.

- Outliers are observations that have a large residual. The leverage statistic and Cook's distance were used to examine whether an outlier was influential and needed to be deleted. Leverage statistics identify observations that are far away from corresponding average predictor values; Cook's distance measures the effect of deleting a given observation (Kutner et al., 2004). Larger Cook's distance values indicate unusual leverage. The rule-of-thumb values for influential outliers are 0.20 or greater for leverage statistics and 1.0 or greater for Cook's distance (Kutner et al., 2004). Casewise diagnostics flags potential outliers, however, there is no violation indicated in Table F.77 according to this rule.

5.8 Critical Factor

The most important predictor was determined through stepwise regression analysis. This type of regression analysis allows for the identification of the unique contribution of each predictor variable to the regression model (Kutner et al., 2004). The stepwise regression was performed on dependent variable behavior intention (BI) and significant independent variables identified in previous regression analysis. Appendix F.6 contains the results of stepwise regression analysis. Change in R^2, ΔR^2, was examined to identify each predictor's contribution (Hayes, 1998).

The stepwise regression reveals that ΔR^2 of performance expectancy (PE) is 0.582 at $p <0.001$. The next variable, perceived enjoyment (PEn), contributes 0.065 to R^2 at $p <0.001$. The third variable, ubiquity (Ubi), contributes to the regression model at $\Delta R^2 =$ 0.0036, $p <0.001$. The last variable in the model, self-management of learning, contributes

0.005 to R^2 at p <0.05. Thus, performance expectancy (PE) is the most important factor in predicting behavior intention and thus acceptance of mobile learning.

A predictive path model, as depicted in Fig.5.4, was constructed based on the results reported in regression analysis. It excludes the variables in the rejected research hypotheses. The values on each link are the beta coefficients from multiple regression that refers to the expected change in the dependent variable per standard deviation increase in the predictor variables (Kutner et al., 2004). The beta coefficients are path coefficients that can be used in examining the possible causal linkage between variables; higher beta coefficient an independent variable has, the more effect it has on dependent variable (Shipley, 2000). Altogether, the model accounted for 70.8% of the variance in independent variable, with performance expectancy (PE) contributing more to behavior intention than the other factors.

5.9 Group Analysis

To investigate differences on mobile learning acceptance, this research compared different student groups across the variable of behavior intention, using the independent samples t-test to compare population means of two different groups and analysis of variance test (ANOVA) to compare population means of multiple groups. Significance level (p-value) was set to 0.05. In both tests, homogeneity of variance was evaluated using Levene statistics to detect a difference in variance and taken into consideration of group comparisons when the analysis was done.

Two independent samples t-tests were conducted. The first one was to determine if there was a significant difference on behavior intention between female and male students on their behavioral intention to use mobile learning; the second was to determine if there was a significant difference between students who had prior mobile learning experience and those who did not. As in Table 5.20, Levene statistics for both tests indicate variance homogeneity at significant levels of 0.559 and 0.299 (p >0.05), respectively. Thus, the two-tail significance for equal variances estimates was used to determine whether the difference existed between two groups of students.

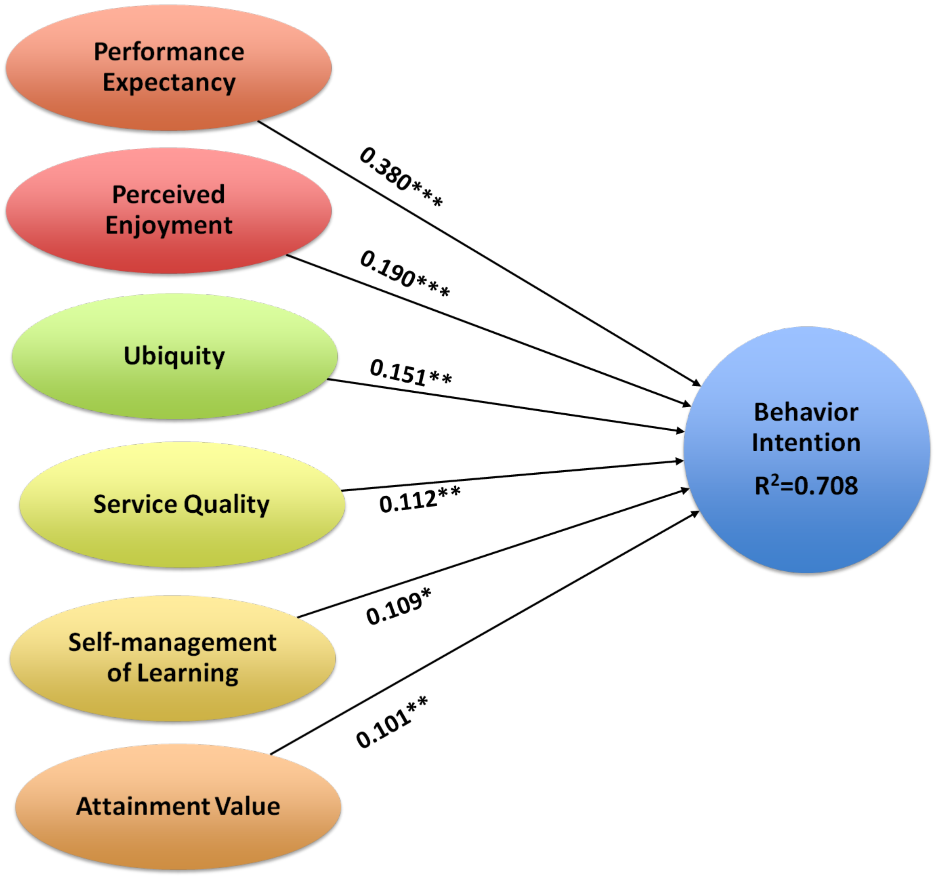

Figure 5.4: Predictive path model with path coefficients
†***p <0.001, **p <0.01, *p <0.05

As presented in Table 5.22 and 5.24, the results for both tests suggested that there was a significant difference between the student groups (p <0.05). The test on gender revealed a significant difference between females and males on intention to use mobile learning, and the females scored higher than the males on the intention to use mobile learning (see Table 5.21). The test on prior mobile learning experience revealed a significant difference between students who had mobile learning experience and those who did not, and the students with prior experience scored higher on behavioral intention (see Table 5.23). This may indicate that students who had prior mobile learning experience have realized its benefits and features that encourage their intentions to use and thus acceptance of mobile learning.

Table 5.20: Levene's test for equality of variances

Groups	F	Sig.
Gender	0.342	0.559
Prior experience	1.081	0.299

Table 5.21: Group statistics of behavior intention by gender

	Gender	N	Mean	Std. Deviation	Std. Error Mean
BI	Male	268	3.813	0.809	0.049
	Female	109	4.006	0.810	0.078

Table 5.22: T-test of gender vs. behavior intention

Dependent Variable	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI (equal variances assumed)	-2.096	375	0.037	-0.193	0.092	-0.373	-0.012

Table 5.23: Group statistics of behavior intention by prior mobile learning experience

	Experiences	N	Mean	Std. Deviation	Std. Error Mean
BI	Yes	305	3.989	0.753	0.043
	No	72	3.361	0.865	0.102

Table 5.24: T-test of prior mobile learning experience vs. behavior intention

Dependent Variable	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI (equal variances assumed)	6.182	375	0	0.628	0.102	0.428	0.828

In addition, multiple t-tests were performed to compare group difference between students based on device ownership, the results of which are presented in Appendix G.1. These tests

revealed that there was no significant difference between students based on the ownership of PDAs and MP3 devices. Only 2.1% of students responded having PDAs, and not all MP3 devices (e.g., iPod nano) can support the features of mobile learning. This may cause insignificant differences based on ownership of PDAs or MP3 devices. However there was a significant difference on behavior intention between students who owned smartphones or tablets and those who did not. Students who owned smartphones or tablets scored higher than non-owners of these devices on behavior intention, which is indicative of their positive views on the use and thus acceptance of mobile learning. Appendix G.2 contains the comparison between students who planned to purchase mobile devices and those who did not. The t-test on planned purchase of PDAs was excluded from this analysis since only one student indicated planning to buy a PDA. The results of the t-tests revealed that there was no significant difference between student groups based on planned purchase of smartphones or MP3 devices. However, there was a significant difference on intention to use mobile learning between students who planned to purchase a tablet and those who did not. The insignificant differences based on planned purchase of smartphones and MP3 players may be caused by high ownership of these devices (81.7% for smartphones, 53.8% for MP3 or similar devices) among respondents. Students who planned to purchase a tablet scored higher on behavioral intention than those who did not, which indicates their higher levels on acceptance of mobile learning.

Three ANOVA tests were conducted to compare mobile learning acceptance across student groups. Respectively, three ANOVA tests were to determine if there was a significant difference on students' behavior intention based on their age, college level, and years of using mobile devices. The students with no experience of using mobile devices were excluded from the last ANOVA test. Appendix G.3 contains group descriptive statistics for these three ANOVA tests. As in Table 5.25, Levene statistics for these tests are 1.332, 0.972, and 0.754 ($p > 0.05$ for all) receptively, indicating equal group variance. The values of F statistics for these three ANOVA tests are, respectively, 1.043, 2.112, and 0.468 ($p > 0.05$ for all). The test results in Table 5.26, 5.27, and 5.28 suggest that there was no significant difference on

students' intention to use mobile learning regardless of their age, college level, and years of using mobile devices.

Table 5.25: Test of Homogeneity of Variances

Group	Levene Statistic	df1	df2	Sig.
Age	1.332	2	373	0.265
College level	0.972	4	372	0.423
Years of experience	0.754	3	364	0.520

Table 5.26: ANOVA test of age vs. behavior intention

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.067	3	0.689	1.043	0.373
Within Groups	246.311	373	0.66		
Total	248.378	376			

Table 5.27: ANOVA test of college level vs. behavior intention

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.514	4	1.379	2.112	0.079
Within Groups	242.863	372	0.653		
Total	248.378	376			

5.10 Summary of Qualitative Findings

The interviews of five voluntary participants were conducted in order to provide more understanding on student perceptions of mobile learning.

Table 5.28: ANOVA test of years of experience vs. behavior intention

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.942	3	0.314	0.468	0.705
Within Groups	244.011	364	0.670		
Total	244.953	367			

These participants were involved in the pilot test, and they were given the opportunity to add comments at the end of the pilot test to elaborate on their feelings and perceptions of mobile learning. All students stated that they used mobile devices to support academic learning, such as Internet searching, accessing to Blackboard, and using educational mobile applications. They all indicated encountering no difficulties or problems when using mobile devices for learning and would recommend mobile learning to others. Students provided comments on the advantages of mobile learning in the interview, including easy access to PPT slides, quick information seeking, no need to carry as many as textbooks or paper materials as before, taking notes or recording lectures during the class for later review, organization and management of learning tasks and assignments. One student expressed concerns about battery life of the device and typing with virtual keyboard. Students perceived that ubiquitous access distinguished mobile learning. They liked to access information or resources anywhere anytime, which made learning more flexible and convenient to them. Two students addressed their needs on free academic applications provided by the university, especially for more sophisticated applications on statistics and other subject matters related to engineering.

In addition, one student who is a non-native English speaker mentioned that she recorded conversations with her project team members and replayed them later since she didn't want any confusion or ambiguities caused by language. This would be one benefit of mobile learning for non-native English speaking students.

5.11 Discussion and Implication

The results by correlation analysis accept the research hypotheses for all predictors. However, regression analysis rejects the research hypotheses for the following predictors: effort expectancy (EE), facilitating conditions (FC), self-efficacy (SE), and social influence (SI). Regression results indicate that performance expectancy (PE), ubiquity (Ubi), attainment value (AV), self-management of learning (SML), service quality (SQ), and perceived enjoyment (PEn) are significant positive predictors of behavioral intention (BI); the intention to use mobile learning will increases with increasing levels of those factors; performance expectancy (PE) is the most critical factor among all. The implication of the results are discussed and addressed in the following.

5.11.1 Significant Predictor

The literature suggests that performance expectancy and perceived relative advantage significantly affect users' attitude and further impacts their behavioral intention to use mobile learning (Carlsson et al., 2006; Liu et al., 2010). In agreement with the literature, the results of regression analysis in this research discover that performance expectancy is the strongest significant positive predictor of acceptance (β=0.384). It is therefore believed that an individual with high level of performance expectancy is more likely to accept mobile learning than an individual with lower level of performance expectancy. Performance expectancy scale items address usefulness in learning, productivity, time on learning activities, and grades. The results from this research suggest that perceived usefulness is essential to students' acceptance and intention to use mobile devices for learning. The more students perceive that mobile learning is useful for learning and improves their performance; the more likely they would engage in mobile learning. In order to increase students' performance expectancy, educators could take advantage of the value-adding characteristics of mobile learning. For example, educators could let students use mobile devices to get timely knowledge, make quick responses or decisions and emphasize on promoting learning productivity by using previously unproductive time, such as traveling and commute time. To facilitate the adoption of mobile

learning, educators and university could also offer students the mobile learning courses that address their long-term benefits. To realize this, the topics of the courses offered by mobile learning need to be well selected and comply with students' long-term objectives, such as academic life development, or have the potential to benefit learners in their future daily lives.

Meanwhile, integrating with service quality factor discussed later, systems designers should focus on developing valuable functions and providing sufficient, up-to-date contents that can fit users' needs, such as enabling users to choose what they want to learn, control their learning progress, and record their learning progress and performance. In this way, students may feel that mobile learning is more personal and flexible, which will in turn increase perceived performance expectancy and facilitate the acceptance of mobile learning.

The second significant positive predictor of intention to use mobile learning found in this research is perceived enjoyment (β=0.190). Results suggest that the more students enjoy mobile learning, the more they will be motivated to engage in mobile learning activities. Given that the use of mobile learning is fully voluntary and that the target user group consists of a large number of people with very diversified backgrounds, making a mobile learning system playful and enjoyable to interact with is crucial for attracting more students to use it. To promote enjoyment of using mobile learning, system designers could integrate cognitive development and system characteristics. For example, cognitive development focuses on individual skills and personal innovativeness; system characteristics focuses on enhancing variety, navigation, ease of use, content accuracy, and interactivity and providing vivid descriptions and visualizations for engagement (Smith et al., 2003; Liu et al., 2010). Furthermore, educators and system designers should consider designing experimental activities for exploration and relating resources to students' experience, knowledge level, interests and needs. In this way, students may feel more absorbed in the task and learning process, which may help them to experience perceived playfulness and in turn increase system users.

Ubiquity and service quality are another two significant factors that positively affect students' intention to use mobile learning (β=0.151 and 0.112, respectively). The items in these two scales address the anytime/anywhere access to learning resources and different

aspects of mobile learning system quality. The literature evidenced that perceived ubiquitous access could affect decisions to adopt mobile services and had a significant influence on behavioral intentions of using the system (Huang and Lin, 2007; Kaigin and Basoglu, 2006; Mallat et al., 2008). Regression results in this research suggest that the more students like ubiquitous access to learning community; the more likely they will use mobile learning. It reveals positive connection between ubiquity and students' acceptance of mobile learning. Student scored high in all aspects of service quality. This indicates the need to be attentive to these issues in order to ensure that these aspects are properly designed and functional in a mobile learning system. Currency and accuracy of content, ease of navigation, understandability of the content, and personalization are very important to the students. Thus, the university and educational practitioners need to address these issues in their mobile learning implementation so that these aspects do not prohibit students from using it. Furthermore, system designers should also pay attention to the importance of content presentation and communication standards, thus making learning contents portable to diverse types of mobile devices.

This research points out that the ubiquitous access to a high-quality mobile learning service will increase students' intention to use mobile learning. Hence, before implementation, universities must ensure that through cooperation with designers, service providers, and administrators mobile learning service is reliable and content is understandable, easy to navigate, current, and accurate. Additionally, customized or personalized services must be sought to address students' individual needs.

Self-management of learning measures the extent to which an individual feels he or she is self-disciplined and can engage in autonomous learning (Smith et al., 2003). Previous research found learners were more likely to engage in mobile learning activities if they had a higher level of autonomous learning skills (Smith et al., 2003). Consistent with literature, the results in this study indicate that self-management of learning is a significant positive predictor of students' intention to use mobile learning (β=0.109) and individuals with a highly autonomous learning ability will be more likely to use mobile learning than those with a lower autonomous learning ability. This finding can help pedagogical policy

makers and instructors design corresponding curricular that can inspire and boost students' capability of self-management of learning. In addition, educators should diligently deliver these curricular to cultivate students' habit of continuous self-learning and lifelong learning, which will in turn increase the number of users of mobile learning systems in the near future. Previous mobile learning literature suggests that mobile technology-enhanced scaffolding and inquiry can be applied in such curricular design. For instance, scaffolds in forms of assessment sheets, decision trees, guidebooks or e-library can be integrated within a mobile learning system so that learners will be more independent, self-motivated, and self-reliant to design and solve their own inquiry during the investigation or experiment (e.g., Hwang and Chang, 2011; Hwang et al., 2010; Liu et al., 2009b); some applications with "mobile scaffolding" can help students monitor and control their own learning process, such as building schedules, organizing tasks and assignments (Shih et al., 2010b). Meanwhile, mobile learning practitioners and developers can target the early adopters of the systems and promote the system features, such as functions of time management, learning content hierarchy control, and learning progress control, to those who have highly autonomous learning abilities.

Attainment value measures personal importance of doing well with regard to self-schema and core personal values, such as achievement (Eccles, 1983). The results in this research indicate that attainment value is a positive significant predictor of students' intention to use mobile learning ($\beta = 0.101$). For educators and university administrators, it is important to cultivate students' positive attitudes that are congruent with their values, commitments and readiness for using mobile learning, by doing which will consequently influence them viewing mobile learning as a useful and easy to use system and thus facilitate the acceptance.

5.11.2 Insignificant Predictors

Effort expectancy measures the degree of ease associated with the use of the particular information system (Venkatesh et al., 2003). Self-efficacy regards the personal belief in one's own ability to complete tasks and reach goals (Schunk, 2008). The results revealed by

regression analysis in the research suggest that effort expectancy and self-efficacy are not significant predictors of behavior intention to use mobile learning. It may be due to the students' familiarity with mobile devices, which is seen in demographic data that 98.4% of students owned mobile devices and 96.6% performed a variety of learning activities on their devices. Hence, using a mobile device appears to be routine for many students and doesn't confine their capabilities of performing learning tasks; they may perceive using mobile devices for learning as similar to using it for other tasks. This finding indicates that, to some extent, technological restrictions seem not to raise significant usability problems that inhibit mobile learning acceptance. This may be largely due to the availability of large-screen mobile devices (e.g., iPad, Samsung Galaxy Note) and efforts from developers in designing mobile learning system and materials in a manner suitable for mobile usage in order to alleviate cumbersome input routines. As a result, the feeling of ease of use was broadly perceived among students, which led to insignificance of effort expectancy and self-efficacy in the study.

Facilitating conditions refer to the availability of resources needed to engage in a behavior (Wang and Shih, 2008b). The items in this scale address whether availability of resources, assistance, support, training and information would affect behavior intention. The regression results in this research suggest that facilitating conditions have no significant effect on students' intention to use mobile learning. This may indicate students' unawareness of university commitment to mobile learning implementation and a lack of involvement. The educational apps can not be simply provided to students; involvement of all stakeholders in the phases of deployment, such as introducing students the benefits of mobile learning, encouraging faculties to use mobile devices in classes, is also important. Universities need to ensure their commitment to implementing mobile learning services and to provide information sharing, training, technical support, and enough resources. This is helpful in system acceptance and usage. Since students may consider the level of support available for a new system (e.g., a mobile learning system) as demonstrating institutional expectations for their usage of the system (Venkatesh et al., 2003).

Although this study ruled out facilitating conditions as a significant predictor of mobile learning acceptance, university administrators could consider informing student of the

strengths of mobile learning to let them perceive the encouragement and support of using it from the university and examining ways to address infrastructure and support to increase usage of mobile learning.

Social influence measures the degree to which an individual perceives that important others believe he or she should use the new system (Venkatesh et al., 2003). The items in this scale address the influence from peers and professors on students' perception toward mobile learning. Contrary with the literature, the regression results in this research suggest that social influence is not a significant predictor of behavior intention to use mobile learning. It may indicate that faculties have not become a positive force in influencing students' perceptions toward mobile learning and they may not perceive mobile devices and technologies can be blended in their instructions. Therefore, university administrators could ensure that faculties are comfortable and acceptable with using mobile learning for their courses by providing adequate training and support so that faculty can influence students about the value placed on using mobile devices for learning. In addition, none courses currently offered by University of Tennessee, Knoxville in iTunes U are related to engineering. Faculties could consider providing their courses on iTunes U or other mobile learning management systems and referring students for utilizing these platforms for academic learning. Majority of students scored higher and agreed that they would like to use mobile learning if perceiving others using it. This may indicate that students are readily accept learning on a mobile device if they perceive that faculties or peers do so and feel it is beneficial. Demographic data revealed that 96.6% students responded using mobile devices for certain learning activities that were most likely informal. Students may feel this as their everyday routines and not perceive that the use of mobile devices could be extended to formal academic learning.

Although social influence was not identified as a significant predictor of intention to use mobile learning in this study, practitioners and educators still need to be aware of its importance since once users start using and become familiar with a new mobile learning system, they may begin to persuade their colleagues and friends to adopt it. Thus, universities could consider investment in identifying early adopters who tend to have a

higher level of personal innovation in order for them to become product champions and in turn influence others' perceptions of mobile learning. Since when the number of users reaches a critical mass point, the number of later mobile learning adopters is likely to grow rapidly (Rogers et al., 2002).

5.12 Summary

In this chapter, research findings were discovered and presented. The survey data were examined and analyzed in order to identify factors associated with student acceptance and use of mobile learning. As a result of exploratory factor analysis, dimensions from survey items were in line with proposed research model. Correlation analysis accepted all hypotheses formulated in this research. However, regression results rejected that effort expectancy, self-efficacy, facilitating conditions, and social influence were positively related to behavior intention. Group analysis revealed that there were significant differences on behavior between females and males and between students who had prior mobile learning experience and those who did not. T-tests on current and planned ownership of mobile devices revealed that there were significant differences between owners of smartphones and tablets and non-owners of these devices and between students who planned to buy a tablets and those who did not. ANOVA tests indicated that there was no significant difference on behavior intention regardless of age, college level, and years of using mobile devices. Overall comments from interviews indicated students' positive view on mobile learning. Significant predictors identified by regression analysis were discussed in the end of this chapter. Their implications on mobile learning system implementation from perspectives of educators, system designers, students, and universities were addressed as well.

Findings in this chapter were ultimately aggregated to answer the research questions and guided to formulate conclusions and recommendations and identify potential areas for future research. Those conclusions, recommendations, and areas for future research are presented in Chapter 6.

Chapter 6

Conclusion

6.1 Research Overview

This research primarily investigated the factors impacting mobile learning acceptance and usage intention. The research model extended the theoretical framework of UTAUT and added new understanding and knowledge body to technology acceptance theory and mobile learning. After presenting the research problems and supporting literature, the data collection instrument was developed based on them. The instrument was validated in a pilot test in terms of face and content validities and internal consistency reliability and then revised based on the pilot test results. As a result, finalized instrument consisted of fifty-two 5-Likert scale questions with regard to students' perceptions of mobile learning and two multiple choice questions on learning resources and activities; all scale reliabilities satisfied research requirement. Before proceeding to statistical analysis, the data were examined in terms of normality and outliers. As a result, the data followed normal distribution, which was the underlying assumption of factor procedure in the next step of research evaluation; no influential outliers were detected and deleted. Discriminant and convergent validities were also examined and verified during the analysis.

To validate research model dimensions, the data were analyzed via principle component analysis with varimax rotation, allowing for the removal of scale items that did not meet the

loading criteria (e.g., factor loadings). After removing those items, reliability alpha was again examined and revised. Revised reliability ranged from 0.700 to 0.921, which met the research requirement. Discriminant and convergent validities revealed no underlying problems with the scales. Before proceeding to the factor analysis, the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test of sphericity ensured appropriateness for this procedure. The factor analysis revealed the latent variable structure and resulted in factor solution that matched the hypothesized structure in the research model.

First research question was concerned with the discovery of factors impacting mobile learning acceptance. Research hypotheses were developed based on the research model in order to answer this question. Hypotheses were first tested using Pearson product-moment correlation coefficients to confirm the relationship existence and its direction and strength, however, this kind of analysis does not consider the pairwise or the partial correlation effect. Therefore, regression analysis was conducted in order to discover the predictors of behavior intention to use mobile learning and test the hypotheses in a multivariate setting. Correlation analysis supported all formulated hypothesis, as depicted in Fig.5.3. Performance expectancy demonstrated the strongest relationship with behavior intention (r=0.763); self-efficacy demonstrated the weakest relationship with behavior intention (r=0.317). Regression analysis suggested that performance expectancy, perceived enjoyment, ubiquity, service quality, self-management of learning, and attainment value were significant predictors of behavior intention to use mobile learning and supported positive hypothesized relationships between behavior intention and those factors. However, regression results did not support positive hypothesized relationships between behavior intention and effort expectancy, self-efficacy, facilitating conditions, and social influence. Performance expectancy was found to be the strongest predictor of behavioral intention via piecewise regression analysis (β=0.380), as shown in Fig.5.4. Based on the hypotheses tests and regression analysis, performance expectancy, perceived enjoyment, ubiquity, service quality, self-management of learning, and attainment value were considered as important factors impacting students' acceptance of using mobile learning, which is shown in Fig.6.1. Altogether, they explained significant portion of the variance in behavioral intention to use mobile learning (R^2=0.708).

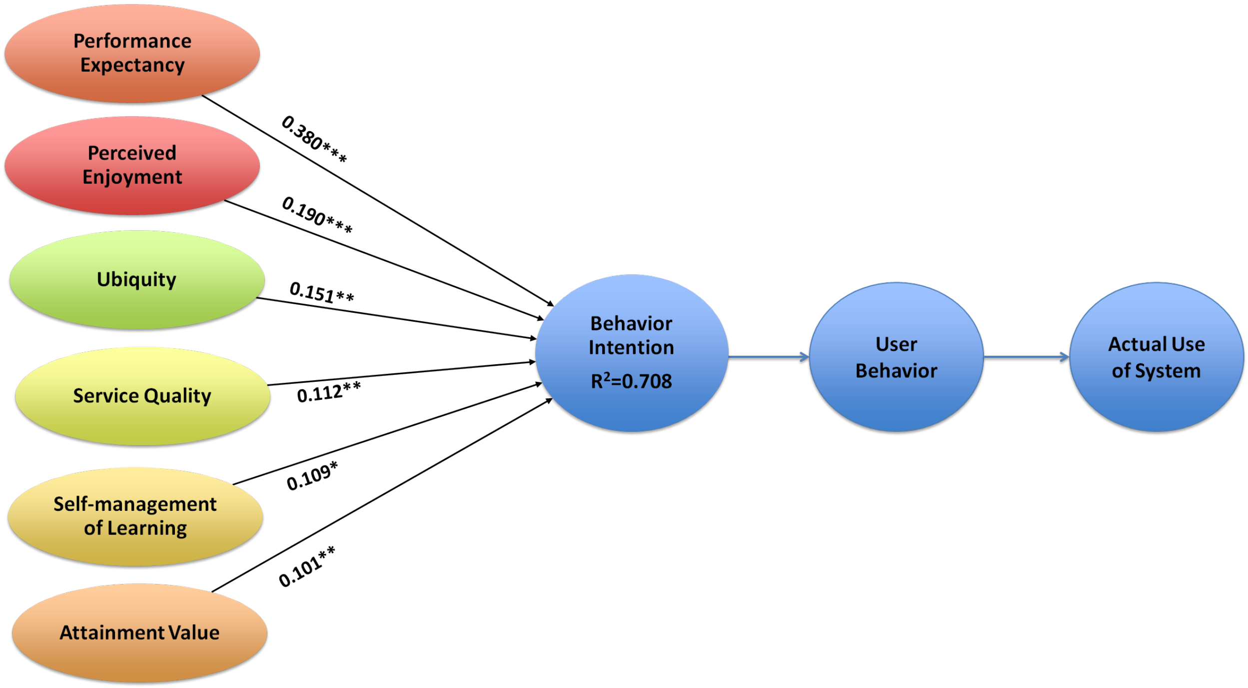

Figure 6.1: Factors impacting mobile learning acceptance
****p <0.001, **p <0.01, *p <0.05

The sample population was 3222 students who were enrolled in College of Engineering for spring semester 2013. Total 377 students responded survey, 28.9 % females and 71.1% males. Demographic data revealed that 80.9% of respondents had mobile learning experience before; ownership of smartphones was high at 81.7%, and 53.8% for MP3 players, 41.7% for tablets, 2.1% for PDAs; only 1.6% students responded not owning mobile devices; 49.3% of respondents indicated future planned purchase of mobile devices; 31.0% planned to purchase smartphone, 29.7% for tablets, 5.8% for MP3 players, and 0.3% for PDAs; only 3.4% responded not using mobile devices for learning purpose; 93.9% students accessed lecture PPT via mobile devices, 92.0% for Blackboard, and 81.4% for videos; 86.7% used mobile devices for sharing information (e.g., emails), 85.7% for checking information online, 75.1% for tracking assignments. These statistics are important because many rich content mobile learning require capabilities of mobile devices. The statistics that show more students own

these devices and are comfortable with using them would probably have an effect on demand for mobile learning and other mobile applications and systems.

To answer second research question, the group analysis was performed based on demographic data in order to understand the impact of student group differences on acceptance of mobile learning. Key groups compared were those related to gender, age, college level, mobile device ownership (current and planned), prior mobile learning experience, and years of experience with using mobile devices. Prior to group analysis, Levene statistics were examined and confirmed equal variances between those student groups. The t-tests and ANOVA tests were then performed between those groups under equal variance assumption. The test on gender groups revealed that there was a significant difference between females and males, and females scored higher on intention to use mobile learning. Group comparison based on prior experience of using mobile devices for learning revealed a significant difference between students who had prior mobile learning experience and those who did not. Students with prior experience scored higher, indicating their high level of mobile learning acceptance. There was a significant difference between owners of smartphones and tablets and non-owners of these devices. This may indicate that students who owned these devices have realized the benefits and features that mobile learning could offer and understood its usefulness. Ownership of PDAs and MP3 players indicated no significant difference between students who owned these devices and those who did not. As to planned ownership, there was a significant difference between students who planned to purchase a tablet and those who did not, but no significant differences based on planned purchase of other devices. ANOVA tests indicated no significant differences between student groups regardless of their age, college level, and years of using mobile devices.

The findings in this research and mobile learning literature shed light on answering third research question. In order to integrate technology advancements with learning, educational systems should be more flexible and be able to reshape in order to handle the dynamics of the latest technology as and when required (Felder and Silverman, 1988; Thornton and Houser, 2004). Such reshaping is not intended to replace traditional classroom instruction and lectures or convert all computer-based learning content into a mobile format but rather to

consider how mobile devices can be used to enhance the learning experience and to strengthen and harmonize its overall strategy. Consequently, educators can utilize such mechanisms to improve their curriculum design in a way that integrates more flexible, accessible, and personalized learning activities so as to facilitate learning process in engineering education.

Education theory is the best element to control teaching and learning innovations (Cochrane, 2006). In light of mobile learning literature, an effective way of improving technology-enhanced engineering education is to combine theory and practice simultaneously in the same lesson. It can be realized by, but not limited to, problem-based learning, inquiry-based learning, or project-based learning, and enhanced by use of mobile technologies (e.g., Shih et al., 2011; Hwang et al., 2010; Chen et al., 2011; Hung et al., 2010; Looi et al., 2010). For example, the instructor can provide peripheral information about a real world problem to the students and allow them to work independently or collaboratively to solve the problem; instead of conventional classroom-instructor-textbooks interactions, instructors can introduce several mobile technology tools as a facilitator or an indirect assistance that can help students do active learning along their learning process. In this way, students may perceive the usefulness of these tools and encouragement and support of using mobile devices for learning from professors; consequently, they may start to use it for both formal (e.g., in classroom) and informal learning (e.g., outside classroom). In present, there are many mobile applications that are suitable for formal and informal learning. For example, some applications are not only an encyclopedia on a certain subject but also provide various functions, such as practicing and solving mathematical problems, testing hypotheses, importing and graphing data, visualizing distributions accordingly while parameter changes, and creating visual controls and indicators for measurement and control systems (e.g., ChE AppSuite, Statistics Visualizer, Data Dashboard for LabVIEW). Students can utilize these tools to facilitate knowledge acquisition, augment learning in a diverse way, and deepen their understandings on a new concept along with instructors' guidance in a classroom. Also, students can use these mobile learning technologies to address their personal needs and make learning more flexible, accessible, and just-in-time outside classroom.

Overall, organizational and pedagogical success of mobile learning requires institutional and instructional preparation and careful planning in infrastructure and strategy development. When administrators, educators, and educational system designers are ready to design or implement a mobile learning initiative, they need to understand the factors impacting mobile learning acceptance and incorporate these factors into their mobile learning initiative.

6.2 Research Contribution

This research demonstrated factors that impact students' acceptance and use of mobile learning through a user acceptance model with a few newly investigated variables. Understanding the determinants of the acceptance and use of mobile learning can enable universities to incorporate these determinants in design and implementation phases, which is essential to the successful delivery of academic, organizational, and instructional information. Before investing in development of mobile learning services and contents, an educational institution should consider factors that influence students' technology acceptance. If students fail to accept mobile learning system offered to them then they would not use it to improve academic performance. The outcome would be wasted budgetary expenses. Thus, this study provides university administrators a means to make effective fiscal and educational decisions regarding mobile learning and to ensure the fiscal and pedagogical success of a mobile learning initiative in a globally competitive environment.

The research has potential implications for system designers also. They should emphasize performance expectancy in the architects of mobile learning while ensuring reliable content and high quality service, since no matter how easy a system is to use, the system will not be used if it is not deemed useful in learning. Moreover, student responses in the survey suggested using mobile devices to access academic services. University of Tennessee, Knoxville currently provides students myUTK service in mobile format and the mobile application for library service, campus map, directory lookup, courses, and campus news and events in iTunes store. The university administration may consider feasibility of providing institution specific social network and expanding mobile applications on other market, such

as Google Play for android devices. In addition, administrations could consider providing mobile access to support other services such as tutors, student success services, workshops, and seminar recordings.

The data gleaned from this study suggested that students were positive about mobile learning. Given the integration of mobile devices into students' daily lives, faculties and instructional designers can consider supporting mobile learning by identifying ways in which mobile devices can be utilized to support both classroom and informal learning in a flexible way. Although mobile learning is capable of offering a new pedagogical approach, students' preferences are not sophisticated. Accessing to lecture PPT slides and sharing information (e.g., email) ranked the highest respectively (see Table 5.4 and 5.5). This suggests that providing more mobile friendly course information and resources could be the first step to implement mobile learning, but universities and educators need to eventually explore more instructional models that employ unique capacities of mobile devices. To educate students on benefits of mobile learning, learning support staff can help them familiarize with using mobile devices to access learning resources and complete various learning tasks and provide recommendations for applications that support learning on smaller devices. The key is understanding student needs, concerns, and the factors impacting their acceptance. In addition, survey and interview findings indicate students' interests in educational mobile applications. This may present potential opportunity for educational system designers and developers. University could consider investing in information technology development for mobile educational applications on different subjects or courses.

Moreover, the application of this research is not limited to higher engineering education. For example, in mobile health, which is a term used for the practice of medicine and public health supported by mobile devices, the system designers could consider incorporating the factors proposed in this research in a mobile health application and stress on perceived usefulness by increasing access to health care and health-related information, improving ability to diagnose and track diseases, and expanding access to ongoing medical education and training for health workers, which would in turn increase mobile health acceptance and system users.

6.3 Limitations

This research study has following limitations:

1. The study is limited to one university setting and geographically limited to Unite States; thus the results may not be generalized.

2. Participants self reported their answers to the research instrument. Bias effects could be presented. Additionally, convenience sampling was use in this research, which has potential bias and limits the generalization of the study.

3. The study is cross-sectional so it measures perceptions and intentions at a single point in time. However, perceptions change over time as individuals gain experience (Venkatesh et al., 2003; Venkatesh and Davis, 2000b). This change has implications for researchers and practitioners who are interested in predicting mobile learning usage over time. Therefore, longitudinal data could be collected in future research to help predict behavior intention over time and enhance the understanding of causality and interrelationships between variables that are important to mobile learning acceptance.

6.4 Future Research

This research study mainly investigated students' acceptance. Thus, there is a great opportunity to investigate mobile learning acceptance among faculties, which may lead to a better understanding of all aspects of mobile learning. Second, this study was conducted in one university setting, and therefore a study at another university could help with generalization of the study and further validate research findings. Third, a more detailed study of the service quality dimensions could be developed not only for presenting relationship between this factor and mobile learning acceptance but also for the purpose of educational system design and mobile learning application development. Fourth, future studies could involve administration and management team. This could benefit university in decision making when it comes to the investment of new information system in an increasingly

mobile work environment. Fifth, a longitudinal study could be conducted to investigate how mobile learning acceptance and usage change over time. For example, universities or faculties could implement mobile learning in classes, and then researchers could compare pre-implementation findings to post implementation at the beginning and end of the semester and cover initial adoption, attitude and intentions to use, and usage behavior over time. Last, future studies could also examine the linkage between students' intention to use mobile learning and actual usage when institutional mobile learning applications have been implemented.

6.5 Conclusion

Overall, this research began with a development of the research model through reviewing relevant literature. Research hypotheses that could answer the research questions were then formulated. An instrument was developed for data collection. Once the data were collected and analyzed, the hypotheses were tested and other findings were interpreted.

Based on the UTAUT and previous literature, this research investigated the factors impacting mobile learning acceptance among engineering college students and explored the differences on behavior intention to use mobile devices for learning based on students' gender, age, college level, prior mobile learning experience, years of using mobile devices, and current and planned ownership of mobile devices. Despite of rapid growth in mobile learning research, there are limited studies in the setting of higher engineering education using technology acceptance models as the theoretical foundation. As the contribution to the body of knowledge in technology acceptance, this research extended and validated UTAUT in the mobile learning context and provided a foundation for similar research in the future.

This study confirmed the ability of performance expectancy, perceived playfulness, attainment value, ubiquity, quality of service, and self-management of learning in predicting students' behavioral intent to use mobile learning. In contrast to previous research, the UTAUT variables of effort expectancy, facilitating conditions and social influence, and newly added variable self-efficacy were found to be insignificant predictors. However, this does not

rule out the use of these variables. More research is needed to determine their significance as predictors.

Universities can use the findings in this research as a foundation on which to build their decision making and strategic planning for mobile learning design and implementation and as guidelines for proper distribution of fiscal and human resources. The components presented in this research can help universities and educators to understand what factors need attention when it comes to a new mobile learning initiative.

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Appendices

A Research Instrument

A.1 Survey Questionnaire

The questionnaire contains three parts, including student's demographics, survey items, and two multiple-choice questions. They are presented in Table A.1, A.2 and A.3 respectively.

Table A.1: Part 1: Student's demographics

What is your age? A. Under 18 B. 18-22 C. 22-26 D. Over 26
What is your college level? A. Freshmen B. Sophomore C. Junior D. Senior E. Graduate
What is your gender? A. Female B. Male
What types of mobile devices do you own? (Check all that apply) A. Smartphone phone B. PDA C. Tablet D. MP3 player or similar (e.g. iPod Touch) E. I don't own any mobile devices.
What types of mobile devices do you plan to purchase? (Check all that apply) A. Smartphone B. PDA C. Tablet D. MP3 player or similar (e.g., iPod Touch) E. I don't plan to purchase any mobile devices.
Have you ever used mobile devices for learning purpose before? A. Yes B. No
Years of experience of using mobile devices: A. 0-1 year B. 2-3 years C. 4-6 years D. More than 6 years E. N/A

The following table contains all items in the survey. The measurement scale is as follows: 1. Completely disagree 2. Disagree 3. Neither agree or disagree 4. Agree 5. Completely agree.

Table A.2: Part 2: Survey items

No.	Items
	Performance Expectancy (PE)
1	I would find using mobile learning enables me to accomplish learning activities and tasks more quickly.
2	I would find using mobile learning is useful for my learning process.
3	I would find using mobile learning would increase my chances of getting a better grade.
4	I would find using mobile learning would likely enhance effectiveness of my learning (do things better and smarter).
5	I would find using mobile learning would likely improve my academic life performance.
	Effort Expectancy (EE)
1	I would find mobile learning is easy to use.
2	I would find it is easy for me to become skillful to use mobile learning.
3	I would find my interaction with mobile learning is clear and understandable to me.
4	I would find learning how to use mobile learning is easy for me.
5	I would find mobile learning is flexible and convenient for my learning.**
	Self-Efficacy (SE)
1	If I had a mobile device and I would use it for completing a learning activity, If someone had showed me how to do it first.
2	If I had a built-in help facility for assistance.
3	Because I think I am very good at using mobile devices.**
4	Even if I had never using mobile learning before.*
5	If I had used similar device before this one to do the same activity**.
	Perceived Enjoyment (PEn)
1	I would find using mobile learning makes learning more enjoyable to me. **
2	I would find using mobile learning to solve problems will be appealing to me.
3	When using mobile learning, I would unlikely realize time elapsed.*
4	When using mobile learning, I would likely forget the work I must do.*
5	I would find using mobile learning will stimulate my curiosity.
6	I would find using mobile learning will lead to my exploration.
	Social Influence (SI)

Continued on next page

Table A.2 continued

No.	Items
1	I would find mobile learning is appealing to me if the majority of my friends or classmates used it.
2	I would use mobile learning if my professor has advocated using it.
3	I would use mobile learning if my professor has referred the importance and effectiveness of using it.
4	I would use mobile learning if my professor has been helpful in the use of mobile learning.
	Facilitating Conditions (FC)
1	I would use mobile learning if my university provides me instruction, training, and assistance when needed.
2	I would use mobile learning if my university provides good technical support.
3	The cost of buying a mobile device(e.g. tablets) would likely hinder my use of mobile learning.**
4	The cost of buying educational apps would likely hinder my use of mobile learning.**
	Self Management of Learning (SML)
1	I am a self-disciplined learner in my studies. **
2	I would find using mobile learning helps me set aside reading and homework time.
3	I would find using mobile learning helps me in managing study time and schedules effectively and complete assignment on time.
4	I would find using mobile learning helps me in fulfilling learning goals for the course.
5	I would find using mobile learning provides me more flexibility in controlling my learning process and choosing what I want to learn.
	Ubiquity (Ubi)
1	I would find using mobile learning increases my access to learning resources.
2	I would find using mobile learning helps me accomplish my studies at a time that is convenient for me.
3	I would find having course materials such as slides, lecture notes, and practice quizzes available on the mobile devices is convenient to me.
4	I would find using mobile learning facilitates my interaction with my classmates (such as group discussion, project work, information sharing). *
5	I would find using mobile learning facilitates my interaction with course professor (such as discussing problems with course professor). **
6	I would find using mobile learning provides learning provides is more convenient on tracking my learning performance (such as checking grades and receiving feedbacks). **
	Attainment Value (AV)

Continued on next page

Table A.2 continued

No.	Items
1	I would find course materials delivered on a mobile device is more engaging to me.**
2	I would find using mobile learning is helpful in achieving learning goals.
3	I would feel a sense of ownership if using mobile learning.
	Service Quality (SQ)
1	In order mobile learning to be effective, It is important to have visually appealing features, such as graphic, video, and appropriate colors and fonts, and good page layout.
2	It is important to have a user-friendly interface.
3	It is important to have content easy to navigate.
4	It is important for the content to be understandable.
5	It is important for the content to be up-to-date and accurate.
6	it is important for the service to be always available. **
7	it is important that mobile learning service to be personalized to understand my needs.
	Behavior Intention (BI)
1	I intend to use mobile learning in my academic life.
2	I intend to use mobile learning more frequently.
3	I would recommend others to use mobile learning.
4	I would enjoy using mobile learning.
5	All things considered, the advantages of using mobile learning outweigh its drawbacks.
6	All things considered, mobile learning is a beneficial idea.
*Item excluded in the final survey instrument **Item removed in exploratory factor analysis	

Table A.3: Part 3: Multiple-choice questions

	Which of the following learning resources would you be interested in accessing on a mobile device? (Check all that apply)
1	Lecture PPT slides
2	Audio recordings (e.g., recordings of lectures, school information)
3	Videos (e.g., course related, recordings of lectures, school information)
4	Print content
5	Ebooks
6	Flashcards and other interactive educational games
7	Hyperlinks to course related reference material
8	Blackboard
9	Educational Apps (e.g. iTunes University, UT mobile)
10	Others
	Which of the following learning activity would you be interested in performing on a mobile device? (Check all that apply)
1	Report on assignments
2	Coordinate tasks for a course project
3	Collect data
4	Write assignment
5	Read and keep track of assignment
6	Share information (email, SMS, et.al)
7	Check information online
8	Take notes
9	Receive guidance on learning activities from course professor
10	Receive administrative messages from the University
11	Discuss topics covered in a given course
12	Undertake simple multiple choice quizzes
13	Supplement print based learning materials/content
14	Keep in touch with classmates
15	Keep in touch with course professor
16	Access/delivering online learning materials/content
17	Don't use mobile devices for learning activities at all.
18	Others

A.2 Interviews Questions

The below are face to face interview questions:

1. Can you tell me about your experiences with mobile learning in this class?
2. Did you encounter any problems while learning through mobile platform? If so, can you elaborate on your experiences?
3. Can you elaborate on possible advantages of using mobile learning?
4. Can you elaborate on possible disadvantages of using mobile learning?
5. How does mobile learning address your learning needs?
6. What factors do you think should be included or important in using mobile learning for your own engineering study? (Such as functionality, interaction, contents, and activities)
7. Would recommend using mobile learning to others? Why?
8. How is learning through mobile devices different from other instructional mediums?
9. Please provide additional comment on experience of using mobile learning.

B IRB Approval

Appendix B: Recruitment Message to Participants

Recruitment Message to the Participants

Dear Engineering Student,

I am a doctoral student of Department Industrial and information at The University of Tennessee, Knoxville. I am conducting a research study to understand the use of mobile technologies in engineering education. I will be working with Dr. Xueping Li and Dr. Aydeniz from College of Education to implement my study.

You will be learning the core course topics through the use of mobile devices, more specifically IPADs. The typical course activities will include developing models and analyzing the models through the use of scientific argumentation.

I am kindly asking you to participate in this study. If you agree to participate in this study, you will be asked: 1) to complete an online survey that looks at your perceptions of mobile learning, 2) allow me to videotape the group-based learning sessions and 3) to let me interview you about your experiences with mobile learning. The interview will last for 30 minutes and focus on your learning experiences and your attitudes and opinions on mobile learning. In addition, I may need to analyze your coursework to better understand how mobile learning helps engineering to achieve the learning goals established by Dr. Li.

While the results of this study may be published, I will not make any references to your names in any of the analysis of publication. In order to protect your identity, I will replace your name with a pseudo name.

I have developed on an online survey to gather data from you. The survey includes questions about the your perception on using mobile technologies (i.e. phones, tables) in engineering education, your uses of mobile technologies in learning your courses and general demographic information about you (i.e. major, gender). This survey consists of 30 items and should take only 30 minutes of your time to complete. You can take the survey online by clicking on the following link ________________________________. Please remember to submit your answers before you leave the system. After you submit your responses, they will be stored on a secure password protected server at The University of Tennessee, Knoxville with an anonymous host name. I will not be able to identify your name. I am only interested in group performance. An interview will be conducted at the end of the project as well to gather data from you. It will take 30 minutes and be conducted at the course classroom. It will be a face-to-face interview that consists of 13 questions regarding your mobile learning experience during this mobile learning project.

Your submission of your responses to the survey questions will be considered as your consent to participate in this study. Your participation in this study is voluntary. The

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Figure B.2: IRB Form B application approval, page 1

participation or non-participation of this project will not impact your course grade. You may withdraw from the study at anytime during this study. You will not be punished for your withdrawal from the study. If you have questions at any time about the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact the researcher at yhuang17@utk.edu. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-3466.

Thank you for your participation.

Sincerely,

Yu Huang
Department of Industrial and information technology
The University of Tennessee,
310 East Stadium Hall
Knoxville, TN 37996-3442
Phone: 646-578-2078

Participating's Signature:____________________________Date:______________

Investigator's signature ______________________________ Date ______________

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Figure B.3: IRB Form B application approval, page 2

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FORM D

Status for Changes and/or Project Termination for Form B Approved Research Involving Human Subjects

Research Compliance Services
Office of Research
The University of Tennessee, Knoxville
1534 White Avenue
Knoxville, TN 37996-1529

1. IRB No.: 8948B
2. Principal Investigator: Yu Huang

   Department: Industrial and Systems Engineering
3. Mailing Address: Room 310, East Stadium Hall, UTK

   City: Knoxville State: TN Zip: 37996
4. Project Title: mLearning for Engineering Education - A Pilot Study

PLEASE CHECK THE APPROPRIATE BOX(S) BELOW (see instructions on next page):

5. ☐ Change of Project Title
6. ☐ Change of Principal or Co-Principal Investigator(s), Other Collaborators, Student Advisor
7. ☒ Change(s) to Project Which Affect Participation of Human Subjects
8. ☒ Change(s) to Informed Consent Forms and/or Assent Form(s)
9. ☐ Additional Locations for Conducting Project
10. ☐ Adverse Events
11. ☐ Project Completed -- Please Close the IRB Files.

12. SIGNATURES

Principal Investigator: [signature] **Date:** 1/23/2013

Student Advisor: [signature] **Date:** 1/24/2013

Departmental Review*: ______ **Date:** ______
***(if required)**

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Figure B.4: IRB Form D application approval

Recruitment Message to the Participants

Dear Engineering Students,

I am a doctoral student of Department of Industrial and Systems Engineering at The University of Tennessee, Knoxville. I am conducting a study to understand the use of mobile learning in engineering education for my dissertation and ask for your participation. I will be working with Dr. Xueping Li and Dr. Aydeniz from College of Education to implement my study.

Mobile learning, for this study, is using mobile devices (e.g., smartphones, tablets, netbooks, et.al) to access educational and university resources anywhere, anytime, whether connected or disconnected from the network.

Participation entails completing a survey (15 minutes) on your perception and experiences with mobile learning. The survey asks demographic questions; however, the survey will not ask for identifiable information. Participation is voluntary and you have the option to end your participation at any time.

At the conclusion of the survey, you will have the opportunity to participate in a drawing for one of four $50 iTunes Gift Cards. The information solicited for the drawing is not linked to the survey to protect your identity. Gift Card winners will be contacted via email one week after closing the survey.

If you would like to participate in this study, please CLICK HERE. This will direct you to the survey. Submission of the survey implies your consent. If you have questions about the survey at any time (or you experience adverse effects as a result of participating in this study), please feel free to contact me at yhuang@utk.edu. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-3466.

Thank you in advance for your participation. Your help is greatly appreciated and critical to this study!

Sincerely,

Yu Huang
The University of Tennessee
Department of Industrial & Systems Engineering

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Figure B.5: IRB Form D application approval-consent form

C Scale Frequency and Descriptive Statistics

Frequencies and descriptive statistics for item PEn3 and PEn4 in perceived enjoyment scale, item Ubi4 in ubiquity scale, and item SE4 for self-efficacy sale are not included since they were removed in pilot test phase.

C.1 Scale Frequencies

Table C.4: Frequency table of PE1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	5	1.3	1.3	1.3
	Disagree	26	6.9	6.9	8.2
	Neither agree or disagree	63	16.7	16.7	24.9
	Agree	175	46.4	46.4	71.4
	Completely Agree	108	28.6	28.6	100
	Total	377	100	100	

Table C.5: Frequency table of PE2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	17	4.5	4.5	5.3
	Neither agree or disagree	61	16.2	16.2	21.5
	Agree	186	49.3	49.3	70.8
	Completely Agree	110	29.2	29.2	100
	Total	377	100	100	

Table C.6: Frequency table of PE3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	10	2.7	2.7	2.7
	Disagree	48	12.7	12.7	15.4
	Neither agree or disagree	145	38.5	38.5	53.8
	Agree	111	29.4	29.4	83.3
	Completely Agree	63	16.7	16.7	100
	Total	377	100	100	

Table C.7: Frequency table of PE4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	10	2.7	2.7	2.7
	Disagree	40	10.6	10.6	13.3
	Neither agree or disagree	102	27.1	27.1	40.3
	Agree	146	38.7	38.7	79
	Completely Agree	79	21	21	100
	Total	377	100	100	

Table C.8: Frequency table of PE5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	8	2.1	2.1	2.1
	Disagree	48	12.7	12.7	14.9
	Neither agree or disagree	92	24.4	24.4	39.3
	Agree	155	41.1	41.1	80.4
	Completely Agree	74	19.6	19.6	100
	Total	377	100	100	

Table C.9: Frequency table of EE1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	21	5.6	5.6	6.4
	Neither agree or disagree	43	11.4	11.4	17.8
	Agree	174	46.2	46.2	63.9
	Completely Agree	136	36.1	36.1	100
	Total	377	100	100	

Table C.10: Frequency table of EE2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	6	1.6	1.6	2.4
	Neither agree or disagree	35	9.3	9.3	11.7
	Agree	187	49.6	49.6	61.3
	Completely Agree	146	38.7	38.7	100
	Total	377	100	100	

Table C.11: Frequency table of EE3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	10	2.7	2.7	3.4
	Neither agree or disagree	67	17.8	17.8	21.2
	Agree	175	46.4	46.4	67.6
	Completely Agree	122	32.4	32.4	100
	Total	377	100	100	

Table C.12: Frequency table of EE4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	7	1.9	1.9	2.4
	Neither agree or disagree	39	10.3	10.3	12.7
	Agree	181	48	48	60.7
	Completely Agree	148	39.3	39.3	100
	Total	377	100	100	

Table C.13: Frequency table of EE5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	13	3.4	3.4	5
	Neither agree or disagree	41	10.9	10.9	15.9
	Agree	162	43	43	58.9
	Completely Agree	155	41.1	41.1	100
	Total	377	100	100	

Table C.14: Frequency table of SE1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	7	1.9	1.9	1.9
	Disagree	40	10.6	10.6	12.5
	Neither agree or disagree	115	30.5	30.5	43
	Agree	139	36.9	36.9	79.8
	Completely Agree	76	20.2	20.2	100
	Total	377	100	100	

Table C.15: Frequency table of SE2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	25	6.6	6.6	8.2
	Neither agree or disagree	107	28.4	28.4	36.6
	Agree	177	46.9	46.9	83.6
	Completely Agree	62	16.4	16.4	100
	Total	377	100	100	

Table C.16: Frequency table of SE3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	12	3.2	3.2	3.7
	Neither agree or disagree	78	20.7	20.7	24.4
	Agree	176	46.7	46.7	71.1
	Completely Agree	109	28.9	28.9	100
	Total	377	100	100	

Table C.17: Frequency table of SE5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	12	3.2	3.2	3.7
	Neither agree or disagree	78	20.7	20.7	24.4
	Agree	176	46.7	46.7	71.1
	Completely Agree	109	28.9	28.9	100
	Total	377	100	100	

Table C.18: Frequency table of PEn1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	13	3.4	3.4	3.4
	Disagree	31	8.2	8.2	11.7
	Neither agree or disagree	104	27.6	27.6	39.3
	Agree	146	38.7	38.7	78
	Completely Agree	83	22	22	100
	Total	377	100	100	

Table C.19: Frequency table of PEn2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	10	2.7	2.7	2.7
	Disagree	31	8.2	8.2	10.9
	Neither agree or disagree	84	22.3	22.3	33.2
	Agree	174	46.2	46.2	79.3
	Completely Agree	78	20.7	20.7	100
	Total	377	100	100	

Table C.20: Frequency table of PEn5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	9	2.4	2.4	2.4
	Disagree	37	9.8	9.8	12.2
	Neither agree or disagree	116	30.8	30.8	43
	Agree	137	36.3	36.3	79.3
	Completely Agree	78	20.7	20.7	100
	Total	377	100	100	

Table C.21: Frequency table of PEn6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	9	2.4	2.4	2.4
	Disagree	32	8.5	8.5	10.9
	Neither agree or disagree	99	26.3	26.3	37.1
	Agree	159	42.2	42.2	79.3
	Completely Agree	78	20.7	20.7	100
	Total	377	100	100	

Table C.22: Frequency table of SI1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	23	6.1	6.1	6.1
	Disagree	30	8	8	14.1
	Neither agree or disagree	125	33.2	33.2	47.2
	Agree	143	37.9	37.9	85.1
	Completely Agree	56	14.9	14.9	100
	Total	377	100	100	

Table C.23: Frequency table of SI2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	7	1.9	1.9	1.9
	Disagree	14	3.7	3.7	5.6
	Neither agree or disagree	74	19.6	19.6	25.2
	Agree	209	55.4	55.4	80.6
	Completely Agree	73	19.4	19.4	100
	Total	377	100	100	

Table C.24: Frequency table of SI3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	9	2.4	2.4	4
	Neither agree or disagree	76	20.2	20.2	24.1
	Agree	196	52	52	76.1
	Completely Agree	90	23.9	23.9	100
	Total	377	100	100	

Table C.25: Frequency table of SI4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	11	2.9	2.9	3.7
	Neither agree or disagree	62	16.4	16.4	20.2
	Agree	198	52.5	52.5	72.7
	Completely Agree	103	27.3	27.3	100
	Total	377	100	100	

Table C.26: Frequency table of FC1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	7	1.9	1.9	1.9
	Disagree	22	5.8	5.8	7.7
	Neither agree or disagree	80	21.2	21.2	28.9
	Agree	179	47.5	47.5	76.4
	Completely Agree	89	23.6	23.6	100
	Total	377	100	100	

Table C.27: Frequency table of FC2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	19	5	5	6.6
	Neither agree or disagree	54	14.3	14.3	21
	Agree	189	50.1	50.1	71.1
	Completely Agree	109	28.9	28.9	100
	Total	377	100	100	

Table C.28: Frequency table of FC3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	21	5.6	5.6	5.6
	Disagree	63	16.7	16.7	22.3
	Neither agree or disagree	72	19.1	19.1	41.4
	Agree	120	31.8	31.8	73.2
	Completely Agree	101	26.8	26.8	100
	Total	377	100	100	

Table C.29: Frequency table of FC4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	12	3.2	3.2	3.2
	Disagree	41	10.9	10.9	14.1
	Neither agree or disagree	47	12.5	12.5	26.5
	Agree	137	36.3	36.3	62.9
	Completely Agree	140	37.1	37.1	100
	Total	377	100	100	

Table C.30: Frequency table of SML1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	14	3.7	3.7	4.2
	Neither agree or disagree	47	12.5	12.5	16.7
	Agree	192	50.9	50.9	67.6
	Completely Agree	122	32.4	32.4	100
	Total	377	100	100	

Table C.31: Frequency table of SML2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	10	2.7	2.7	2.7
	Disagree	86	22.8	22.8	25.5
	Neither agree or disagree	113	30	30	55.4
	Agree	122	32.4	32.4	87.8
	Completely Agree	46	12.2	12.2	100
	Total	377	100	100	

Table C.32: Frequency table of SML3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	11	2.9	2.9	2.9
	Disagree	64	17	17	19.9
	Neither agree or disagree	101	26.8	26.8	46.7
	Agree	134	35.5	35.5	82.2
	Completely Agree	67	17.8	17.8	100
	Total	377	100	100	

Table C.33: Frequency table of SML4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	12	3.2	3.2	3.2
	Disagree	37	9.8	9.8	13
	Neither agree or disagree	126	33.4	33.4	46.4
	Agree	141	37.4	37.4	83.8
	Completely Agree	61	16.2	16.2	100
	Total	377	100	100	

Table C.34: Frequency table of SML5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	13	3.4	3.4	3.4
	Disagree	37	9.8	9.8	13.3
	Neither agree or disagree	88	23.3	23.3	36.6
	Agree	161	42.7	42.7	79.3
	Completely Agree	78	20.7	20.7	100
	Total	377	100	100	

Table C.35: Frequency table of Ubi1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	5	1.3	1.3	1.3
	Disagree	13	3.4	3.4	4.8
	Neither agree or disagree	39	10.3	10.3	15.1
	Agree	194	51.5	51.5	66.6
	Completely Agree	126	33.4	33.4	100
	Total	377	100	100	

Table C.36: Frequency table of Ubi2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	4	1.1	1.1	1.1
	Disagree	15	4	4	5
	Neither agree or disagree	68	18	18	23.1
	Agree	164	43.5	43.5	66.6
	Completely Agree	126	33.4	33.4	100
	Total	377	100	100	

Table C.37: Frequency table of Ubi3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	1	0.3	0.3	0.3
	Disagree	3	0.8	0.8	1.1
	Neither agree or disagree	32	8.5	8.5	9.5
	Agree	150	39.8	39.8	49.3
	Completely Agree	191	50.7	50.7	100
	Total	377	100	100	

Table C.38: Frequency table of Ubi5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	10	2.7	2.7	2.7
	Disagree	41	10.9	10.9	13.5
	Neither agree or disagree	76	20.2	20.2	33.7
	Agree	160	42.4	42.4	76.1
	Completely Agree	90	23.9	23.9	100
	Total	377	100	100	

Table C.39: Frequency table of Ubi6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	9	2.4	2.4	2.9
	Neither agree or disagree	47	12.5	12.5	15.4
	Agree	172	45.6	45.6	61
	Completely Agree	147	39	39	100
	Total	377	100	100	

Table C.40: Frequency table of AV1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	14	3.7	3.7	3.7
	Disagree	48	12.7	12.7	16.4
	Neither agree or disagree	120	31.8	31.8	48.3
	Agree	126	33.4	33.4	81.7
	Completely Agree	69	18.3	18.3	100
	Total	377	100	100	

Table C.41: Frequency table of AV2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	35	9.3	9.3	9.3
	Disagree	58	15.4	15.4	24.7
	Neither agree or disagree	161	42.7	42.7	67.4
	Agree	82	21.8	21.8	89.1
	Completely Agree	41	10.9	10.9	100
	Total	377	100	100	

Table C.42: Frequency table of AV3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	28	7.4	7.4	7.4
	Disagree	60	15.9	15.9	23.3
	Neither agree or disagree	150	39.8	39.8	63.1
	Agree	92	24.4	24.4	87.5
	Completely Agree	47	12.5	12.5	100
	Total	377	100	100	

Table C.43: Frequency table of SQ1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	4	1.1	1.1	1.1
	Disagree	6	1.6	1.6	2.7
	Neither agree or disagree	34	9	9	11.7
	Agree	156	41.4	41.4	53.1
	Completely Agree	177	46.9	46.9	100
	Total	377	100	100	

Table C.44: Frequency table of SQ2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	1	0.3	0.3	0.3
	Neither agree or disagree	19	5	5	5.3
	Agree	103	27.3	27.3	32.6
	Completely Agree	254	67.4	67.4	100
	Total	377	100	100	

Table C.45: Frequency table of SQ3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	1	0.3	0.3	0.3
	Disagree	2	0.5	0.5	0.8
	Neither agree or disagree	20	5.3	5.3	6.1
	Agree	104	27.6	27.6	33.7
	Completely Agree	250	66.3	66.3	100
	Total	377	100	100	

Table C.46: Frequency table of SQ4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Disagree	1	0.3	0.3	0.8
	Neither agree or disagree	21	5.6	5.6	6.4
	Agree	102	27.1	27.1	33.4
	Completely Agree	251	66.6	66.6	100
	Total	377	100	100	

Table C.47: Frequency table of SQ5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	2	0.5	0.5	0.5
	Neither agree or disagree	18	4.8	4.8	5.3
	Agree	97	25.7	25.7	31
	Completely Agree	260	69	69	100
	Total	377	100	100	

Table C.48: Frequency table of SQ6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	15	4	4	4.8
	Neither agree or disagree	92	24.4	24.4	29.2
	Agree	160	42.4	42.4	71.6
	Completely Agree	107	28.4	28.4	100
	Total	377	100	100	

Table C.49: Frequency table of SQ7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	1	0.3	0.3	0.3
	Disagree	6	1.6	1.6	1.9
	Neither agree or disagree	27	7.2	7.2	9
	Agree	129	34.2	34.2	43.2
	Completely Agree	214	56.8	56.8	100
	Total	377	100	100	

Table C.50: Frequency table of BI1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	5	1.3	1.3	1.3
	Disagree	29	7.7	7.7	9
	Neither agree or disagree	68	18	18	27.1
	Agree	164	43.5	43.5	70.6
	Completely Agree	111	29.4	29.4	100
	Total	377	100	100	

Table C.51: Frequency table of BI2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	43	11.4	11.4	13
	Neither agree or disagree	111	29.4	29.4	42.4
	Agree	132	35	35	77.5
	Completely Agree	85	22.5	22.5	100
	Total	377	100	100	

Table C.52: Frequency table of BI3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	12	3.2	3.2	3.2
	Disagree	16	4.2	4.2	7.4
	Neither agree or disagree	112	29.7	29.7	37.1
	Agree	140	37.1	37.1	74.3
	Completely Agree	97	25.7	25.7	100
	Total	377	100	100	

Table C.53: Frequency table of BI4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	7	1.9	1.9	1.9
	Disagree	18	4.8	4.8	6.6
	Neither agree or disagree	74	19.6	19.6	26.3
	Agree	175	46.4	46.4	72.7
	Completely Agree	103	27.3	27.3	100
	Total	377	100	100	

Table C.54: Frequency table of BI5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	6	1.6	1.6	1.6
	Disagree	19	5	5	6.6
	Neither agree or disagree	97	25.7	25.7	32.4
	Agree	152	40.3	40.3	72.7
	Completely Agree	103	27.3	27.3	100
	Total	377	100	100	

Table C.55: Frequency table of BI6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Completely Disagree	3	0.8	0.8	0.8
	Disagree	10	2.7	2.7	3.4
	Neither agree or disagree	65	17.2	17.2	20.7
	Agree	180	47.7	47.7	68.4
	Completely Agree	119	31.6	31.6	100
	Total	377	100	100	

C.2 Scale Descriptive Statistics

Table C.56: Descriptive statistics for all survey items

Item	N	Min.	Max.	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
PE1	377	1	5	3.94	0.921	-0.83	0.126	0.47	0.251
PE2	377	1	5	4.02	0.841	-0.812	0.126	0.743	0.251
PE3	377	1	5	3.45	0.999	-0.138	0.126	-0.441	0.251
PE4	377	1	5	3.65	1.011	-0.492	0.126	-0.252	0.251
PE5	377	1	5	3.63	1.005	-0.482	0.126	-0.364	0.251
EE1	377	1	5	4.11	0.871	-1.019	0.126	0.96	0.251
EE2	377	1	5	4.24	0.748	-1.11	0.126	2.259	0.251
EE3	377	1	5	4.07	0.822	-0.763	0.126	0.692	0.251
EE4	377	1	5	4.24	0.751	-0.986	0.126	1.536	0.251
EE5	377	1	5	4.19	0.877	-1.251	0.126	1.843	0.251
SE1	377	1	5	3.63	0.981	-0.355	0.126	-0.386	0.251
SE2	377	1	5	3.7	0.8769	-0.543	0.126	0.321	0.251
SE3	377	1	5	4	0.82	-0.586	0.126	0.213	0.251
SE5	377	2	5	4	0.767	-0.458	0.126	-0.081	0.251
PEn1	377	1	5	3.68	1.017	-0.586	0.126	-0.012	0.251
PEn2	377	1	5	3.74	0.966	-0.725	0.126	0.304	0.251
PEn5	377	1	5	3.63	0.994	-0.4	0.126	-0.292	0.251
PEn6	377	1	5	3.7	0.969	-0.576	0.126	0.033	0.251
SI1	377	1	5	3.47	1.037	-0.573	0.126	0.077	0.251
SI2	377	1	5	3.87	0.831	-0.924	0.126	1.551	0.251
SI3	377	1	5	3.94	0.823	-0.841	0.126	1.391	0.251
SI4	377	1	5	4.03	0.792	-0.79	0.126	1.091	0.251

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Table C.2 continued

Item	N	Min.	Max.	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
FC1	377	1	5	3.85	0.91	-0.765	0.126	0.587	0.251
FC2	377	1	5	4	0.883	-0.998	0.126	1.205	0.251
FC3	377	1	5	3.58	1.205	-0.486	0.126	-0.795	0.251
FC4	377	1	5	3.93	1.103	-0.933	0.126	0.042	0.251
SML1	377	1	5	4.11	0.797	-0.896	0.126	1.083	0.251
SML2	377	1	5	3.29	1.033	-0.072	0.126	-0.797	0.251
SML3	377	1	5	3.48	1.06	-0.305	0.126	-0.671	0.251
SML4	377	1	5	3.54	0.981	-0.407	0.126	-0.107	0.251
SML5	377	1	5	3.67	1.02	-0.659	0.126	0.017	0.251
Ubi1	377	1	5	4.12	0.826	-1.171	0.126	2.063	0.251
Ubi2	377	1	5	4.04	0.877	-0.819	0.126	0.582	0.251
Ubi3	377	1	5	4.4	0.7	-1.058	0.126	1.289	0.251
Ubi5	377	1	5	3.74	1.024	-0.671	0.126	-0.103	0.251
Ubi6	377	1	5	4.2	0.787	-0.933	0.126	1.066	0.251
AV1	377	1	5	3.5	1.047	-0.339	0.126	-0.43	0.251
AV2	377	1	5	3.1	1.082	-0.115	0.126	-0.361	0.251
AV3	377	1	5	3.19	1.081	-0.133	0.126	-0.432	0.251
BI1	377	1	5	3.92	0.948	-0.764	0.126	0.186	0.251
BI2	377	1	5	3.66	1.002	-0.336	0.126	-0.55	0.251
BI3	377	1	5	3.78	0.982	-0.63	0.126	0.268	0.251
BI4	377	1	5	3.93	0.908	-0.839	0.126	0.762	0.251
BI5	377	1	5	3.87	0.927	-0.598	0.126	0.122	0.251
BI6	377	1	5	4.07	0.814	-0.776	0.126	0.798	0.251
SQ1	377	1	5	4.32	0.788	-1.344	0.126	2.572	0.251

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Table C.2 continued

Item	N	Min.	Max.	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
SQ2	377	1	5	4.62	0.609	-1.624	0.126	3.294	0.251
SQ3	377	1	5	4.59	0.642	-1.678	0.126	3.402	0.251
SQ4	377	1	5	4.59	0.659	-1.845	0.126	4.571	0.251
SQ5	377	1	5	4.63	0.628	-1.975	0.126	5.519	0.251
SQ6	377	1	5	3.94	0.87	-0.535	0.126	0.005	0.251
SQ7	377	1	5	4.46	0.721	-1.365	0.126	2.04	0.251

D Exploratory Factor Analysis

Table D.57: Total variance explained by factors

Component	Eigenvalues		
	Total	% of Variance	Cumulative%
1	5.03	12.269	12.269
2	4.54	11.073	23.342
3	3.618	8.825	32.167
4	3.427	8.36	40.526
5	3.02	7.366	47.893
6	3	7.316	55.209
7	1.873	4.569	59.778
8	1.857	4.529	64.307
9	1.834	4.474	68.781
10	1.682	4.103	72.884
11	1.507	3.676	76.56

Table D.58: Measures of sampling adequacy (MSA) for all survey items

Item	MSA	Item	MSA
PE1	0.963	SML1	0.822
PE2	0.971	SML2	0.942
PE3	0.958	SML3	0.950
PE4	0.976	SML4	0.967
PE5	0.964	SML5	0.978
EE1	0.954	Ubi1	0.973
EE2	0.946	Ubi2	0.953
EE3	0.951	Ubi3	0.958
EE4	0.924	Ubi5	0.949
EE5	0.971	Ubi6	0.933
SE1	0.885	AV1	0.973
SE2	0.889	AV2	0.903
SE3	0.930	AV3	0.914
SE5	0.913	BI1	0.968
PEn1	0.971	BI2	0.965
PEn2	0.973	BI3	0.958
PEn5	0.950	BI4	0.968
PEn6	0.956	BI5	0.962
SI1	0.953	BI6	0.965
SI2	0.945	SQ1	0.929
SI3	0.919	SQ2	0.874
SI4	0.948	SQ3	0.870
FC1	0.906	SQ4	0.908
FC2	0.895	SQ5	0.915
FC3	0.478	SQ6	0.880
FC4	0.477	SQ7	0.936

Table D.59: Factor loadings

	Component										
Item	1	2	3	4	5	6	7	8	9	10	11
BI1	0.752										
BI2	0.72										
BI3	0.745										
BI4	0.665										
BI5	0.733										
BI6	0.695										
SQ1		0.71									
SQ2		0.879									
SQ3		0.884									
SQ4		0.821									
SQ5		0.869									
SQ7		0.687									
PE1			0.665								
PE2			0.621								
PE3			0.71								
PE4			0.668								
PE5			0.714								
EE1				0.682							
EE2				0.808							
EE3				0.796							
EE4				0.807							
SML2					0.808						
SML3					0.725						
SML4					0.634						
SML5					0.6						
SI1						0.689					
SI2						0.756					
SI3						0.764					
SI4						0.677					
AV2							0.804				
AV3							0.789				
PEn2								0.549			
PEn5								0.678			
PEn6								0.639			
FC1									0.777		
FC2									0.804		
SE1										0.799	
SE2										0.812	
Ubi1											0.588

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Table D.59 continued

	Component										
Item	1	2	3	4	5	6	7	8	9	10	11
Ubi2											0.527
Ubi3											0.679

*Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 7 iterations.

E Validity Analysis

E.1 Convergent Validity

Table E.60: Pearson product moment correlation for attainment value (AV)

		AV2	AV3
AV2	Pearson Correlation	1	.853**
	Sig. (2-tailed)		0
	N	377	377
AV3	Pearson Correlation	.853**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Table E.61: Pearson product moment correlation for facilitating conditions (FC)

		FC1	FC2
FC1	Pearson Correlation	1	.728**
	Sig. (2-tailed)		0
	N	377	377
FC2	Pearson Correlation	.728**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Table E.62: Pearson product moment correlation for self-efficacy (SE)

		SE1	SE2
SE1	Pearson Correlation	1	.535**
	Sig. (2-tailed)		0
	N	377	377
SE2	Pearson Correlation	.535**	1
	Sig. (2-tailed)	0	
	N	377	377
** Correlation is significant at the 0.01 level (2-tailed).			

Table E.63: Pearson product moment correlation for ubiquity (Ubi)

		Ubi1	Ubi2	Ubi3
Ubi1	Pearson Correlation	1	.591**	.528**
	Sig. (2-tailed)		0	0
	N	377	377	377
Ubi2	Pearson Correlation	.591**	1	.475**
	Sig. (2-tailed)	0		0
	N	377	377	377
Ubi3	Pearson Correlation	.528**	.475**	1
	Sig. (2-tailed)	0	0	
	N	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).				

Table E.64: Pearson product moment correlation for behavior intention (BI)

		BI1	BI2	BI3	BI4	BI5	BI6
BI1	Pearson Correlation	1	.764**	.761**	.670**	.678**	.644**
	Sig. (2-tailed)		0	0	0	0	0
	N	377	377	377	377	377	377
BI2	Pearson Correlation	.764**	1	.780**	.723**	.646**	.612**
	Sig. (2-tailed)	0		0	0	0	0
	N	377	377	377	377	377	377
BI3	Pearson Correlation	.761**	.780**	1	.802**	.707**	.710**
	Sig. (2-tailed)	0	0		0	0	0
	N	377	377	377	377	377	377
BI4	Pearson Correlation	.670**	.723**	.802**	1	.718**	.719**
	Sig. (2-tailed)	0	0	0		0	0
	N	377	377	377	377	377	377
BI5	Pearson Correlation	.678**	.646**	.707**	.718**	1	.786**
	Sig. (2-tailed)	0	0	0	0		0
	N	377	377	377	377	377	377
BI6	Pearson Correlation	.644**	.612**	.710**	.719**	.786**	1
	Sig. (2-tailed)	0	0	0	0	0	
	N	377	377	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).							

Table E.65: Pearson product moment correlation for effort expectancy (EE)

		EE1	EE2	EE3	EE4
EE1	Pearson Correlation	1	.632**	.617**	.590**
	Sig. (2-tailed)		0	0	0
	N	377	377	377	377
EE2	Pearson Correlation	.632**	1	.712**	.671**
	Sig. (2-tailed)	0		0	0
	N	377	377	377	377
EE3	Pearson Correlation	.617**	.712**	1	.667**
	Sig. (2-tailed)	0	0		0
	N	377	377	377	377
EE4	Pearson Correlation	.590**	.671**	.667**	1
	Sig. (2-tailed)	0	0	0	
	N	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).					

Table E.66: Pearson product moment correlation for perceieved enjoyment (PEn)

		PEn2	PEn5	PEn6
PEn2	Pearson Correlation	1	.664**	.600**
	Sig. (2-tailed)		0	0
	N	377	377	377
PEn5	Pearson Correlation	.664**	1	.756**
	Sig. (2-tailed)	0		0
	N	377	377	377
PEn6	Pearson Correlation	.600**	.756**	1
	Sig. (2-tailed)	0	0	
	N	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).				

Table E.67: Pearson product moment correlation for performance expectancy (PE)

		PE1	PE2	PE3	PE4	PE5
PE1	Pearson Correlation	1	.702**	.633**	.655**	.687**
	Sig. (2-tailed)		0	0	0	0
	N	377	377	377	377	377
PE2	Pearson Correlation	.702**	1	.621**	.639**	.681**
	Sig. (2-tailed)	0		0	0	0
	N	377	377	377	377	377
PE3	Pearson Correlation	.633**	.621**	1	.687**	.726**
	Sig. (2-tailed)	0	0		0	0
	N	377	377	377	377	377
PE4	Pearson Correlation	.655**	.639**	.687**	1	.750**
	Sig. (2-tailed)	0	0	0		0
	N	377	377	377	377	377
PE5	Pearson Correlation	.687**	.681**	.726**	.750**	1
	Sig. (2-tailed)	0	0	0	0	
	N	377	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).						

Table E.68: Pearson product moment correlation for self-mangemeng of learning (SML)

		SML2	SML3	SML4	SML5
SML2	Pearson Correlation	1	.690**	.628**	.528**
	Sig. (2-tailed)		0	0	0
	N	377	377	377	377
SML3	Pearson Correlation	.690**	1	.725**	.602**
	Sig. (2-tailed)	0		0	0
	N	377	377	377	377
SML4	Pearson Correlation	.628**	.725**	1	.643**
	Sig. (2-tailed)	0	0		0
	N	377	377	377	377
SML5	Pearson Correlation	.528**	.602**	.643**	1
	Sig. (2-tailed)	0	0	0	
	N	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).					

Table E.69: Pearson product moment correlation for service quality (SQ)

		SQ1	SQ2	SQ3	SQ4	SQ5	SQ7
SQ1	Pearson Correlation	1	.620**	.571**	.537**	.583**	.601**
	Sig. (2-tailed)		0	0	0	0	0
	N	377	377	377	377	377	377
SQ2	Pearson Correlation	.620**	1	.808**	.672**	.722**	.571**
	Sig. (2-tailed)	0		0	0	0	0
	N	377	377	377	377	377	377
SQ3	Pearson Correlation	.571**	.808**	1	.721**	.748**	.593**
	Sig. (2-tailed)	0	0		0	0	0
	N	377	377	377	377	377	377
SQ4	Pearson Correlation	.537**	.672**	.721**	1	.771**	.597**
	Sig. (2-tailed)	0	0	0		0	0
	N	377	377	377	377	377	377
SQ5	Pearson Correlation	.583**	.722**	.748**	.771**	1	.589**
	Sig. (2-tailed)	0	0	0	0		0
	N	377	377	377	377	377	377
SQ7	Pearson Correlation	.601**	.571**	.593**	.597**	.589**	1
	Sig. (2-tailed)	0	0	0	0	0	
	N	377	377	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).							

Table E.70: Pearson product moment correlation for social influence (SI)

		SI1	SI2	SI3	SI4
SI1	Pearson Correlation	1	.611**	.588**	.510**
	Sig. (2-tailed)		0	0	0
	N	377	377	377	377
SI2	Pearson Correlation	.611**	1	.689**	.644**
	Sig. (2-tailed)	0		0	0
	N	377	377	377	377
SI3	Pearson Correlation	.588**	.689**	1	.643**
	Sig. (2-tailed)	0	0		0
	N	377	377	377	377
SI4	Pearson Correlation	.510**	.644**	.643**	1
	Sig. (2-tailed)	0	0	0	
	N	377	377	377	377
** Correlation is significant at the 0.01 level (2-tailed).					

E.2 Discriminant Validity

Table E.71: Discriminant Validity Analysis

Scale	BI	PE	EE	SE	PEn	SI	FC	SML	Ubi	AV	SQ
BI	1.000										
PE	0.818	1.000									
EE	0.603	0.644	1.000								
SE	0.401	0.433	0.255	1.000							
PEn	0.800	0.786	0.648	0.392	1.000						
SI	0.586	0.563	0.447	0.521	0.584	1.000					
FC	0.514	0.488	0.349	0.659	0.532	0.662	1.000				
SML	0.752	0.754	0.574	0.449	0.777	0.652	0.554	1.000			
Ubi	0.784	0.737	0.609	0.480	0.734	0.649	0.595	0.784	1.000		
AV	0.601	0.574	0.375	0.321	0.647	0.530	0.415	0.650	0.481	1.000	
SQ	0.355	0.190	0.277	0.238	0.259	0.382	0.277	0.223	0.473	0.079	1.000
*Off-diagonal values are less than 0.85											

F Regression Analysis

F.1 Regression Analysis Results for Dependent Variable Behavior Intention

Table F.72: Descriptive statistics for dependent variable and independent variables

	Mean	Std. Deviation	N
BI	3.8691	0.81276	377
PE	3.7374	0.82392	377
EE	4.1638	0.68431	377
SE	3.6645	0.81427	377
PEn	3.6914	0.86362	377
SI	3.8276	0.72529	377
FC	3.9244	0.83331	377
SML	3.4947	0.87251	377
Ubi	4.1874	0.66595	377
AV	3.1406	1.04111	377
SQ	4.5323	0.55643	377

Table F.73: Model summary of regression analysis[b]

Model Summary				
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.842[a]	0.708	0.7	0.445
Change Statistics				
R Square Change	F Change	df1	df2	Sig. F Change
0.708	88.812	10	366	0
a Dependent Variable: BI b Predictors: (Constant), SQ, AV, SE, EE, FC, Ubi, SI, PEn, SML, PE				

Table F.74: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	175.892	10	17.589	88.812	.000[b]
	Residual	72.486	366	0.198		
	Total	248.378	376			
a Dependent Variable: BI						
b Predictors: (Constant), SQ, AV, SE, EE, FC, Ubi, SI, PEn, SML, PE						

Table F.75: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	Collinearity Statistics	
		B	Std. Error				Tolerance	VIF
1	(Constant)	-0.417	0.218		-1.912	0.057		
	PE	0.375	0.045	0.380	8.234	0	0.375	2.667
	EE	0.024	0.044	0.020	0.546	0.585	0.568	1.76
	SE	-0.029	0.034	-0.029	-0.867	0.387	0.705	1.418
	PEn	0.179	0.042	0.190	4.248	0	0.398	2.513
	SI	0.002	0.045	0.002	0.04	0.968	0.501	1.996
	FC	0.026	0.037	0.027	0.715	0.475	0.559	1.788
	SML	0.102	0.042	0.109	2.435	0.015	0.397	2.52
	Ubi	0.185	0.054	0.151	3.419	0.001	0.407	2.455
	AV	0.079	0.03	0.101	2.648	0.008	0.547	1.83
	SQ	0.164	0.048	0.112	3.411	0.001	0.733	1.364
a Dependent Variable: BI								

F.2 Normality of Residuals Assumption

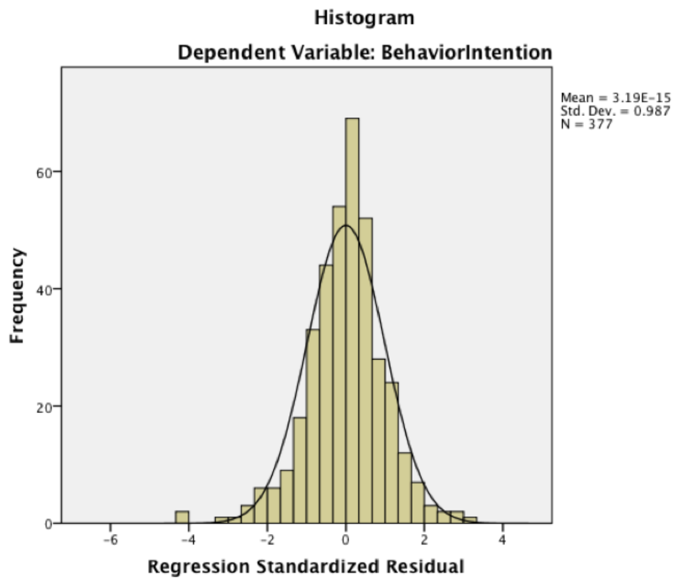

Figure F.6: Histogram of regression standardized residual

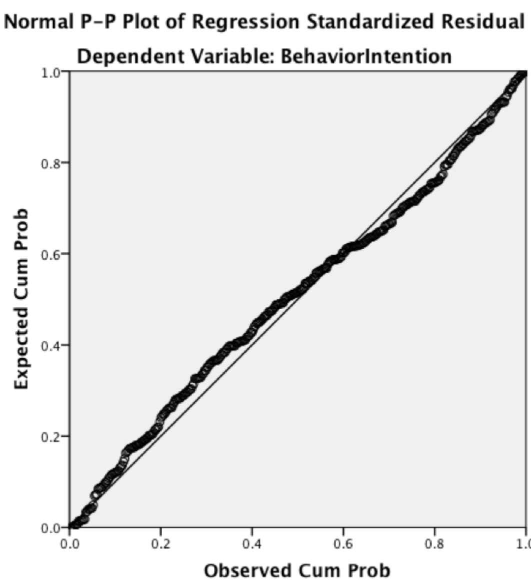

Figure F.7: Normal P-P plot of regression standardized residual

F.3 Constant Variance of Residuals Assumption

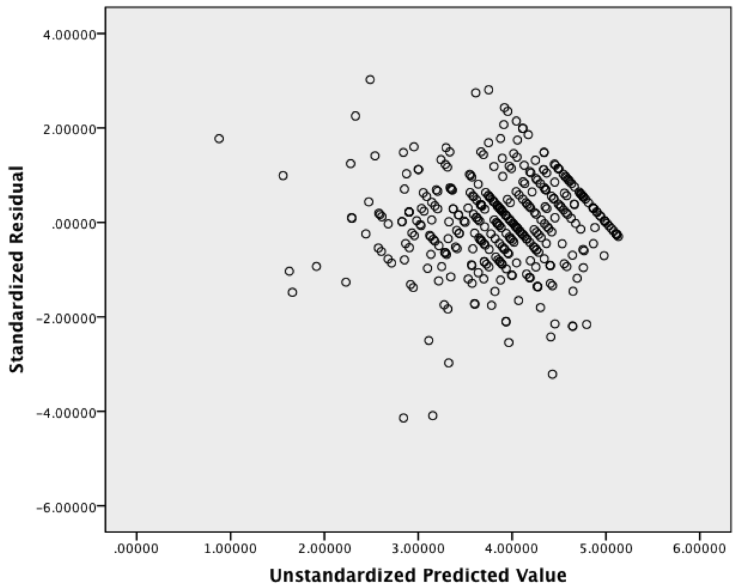

Figure F.8: Constant variance of the residuals

F.4 Outlier Assumption

Table F.76: Casewise diagnostics[a]

Case Number	Std. Residual	BI	Predicted Value	Residual
144	-4.092	1.33	3.1543	-1.82093
258	3.024	3.83	2.4876	1.34573
323	-4.142	1	2.8431	-1.84313
340	-3.214	3	4.4303	-1.43035
a Dependent Variable: BI				

Table F.77: Cook's distance and leverage value

Case Number	Cook's Distance	Leverage value
144	0.16156	0.08559
258	0.05723	0.05809
323	0.38628	0.16781
340	0.10424	0.08894

F.5 Linearity Assumption

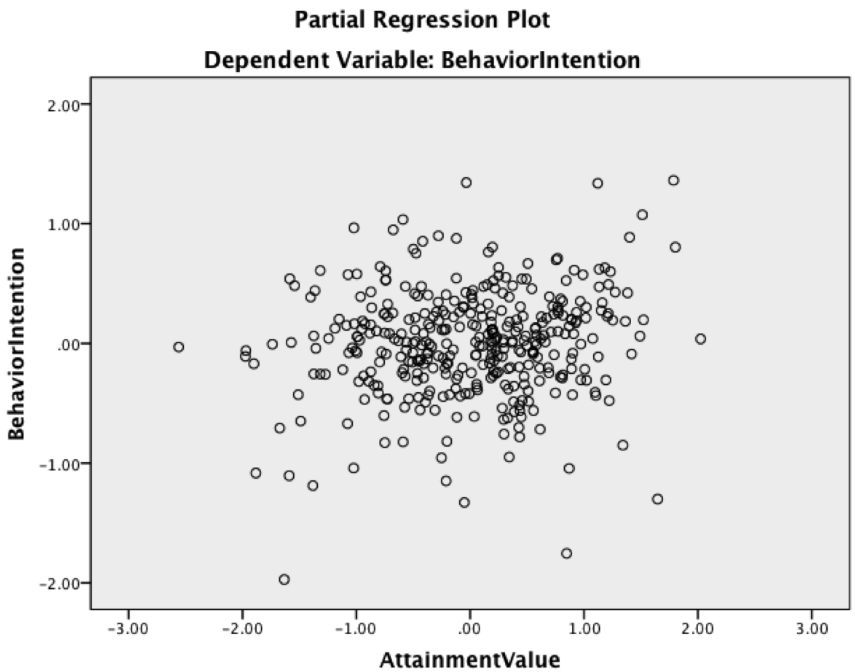

Figure F.9: Partial regression plot BI vs. AV

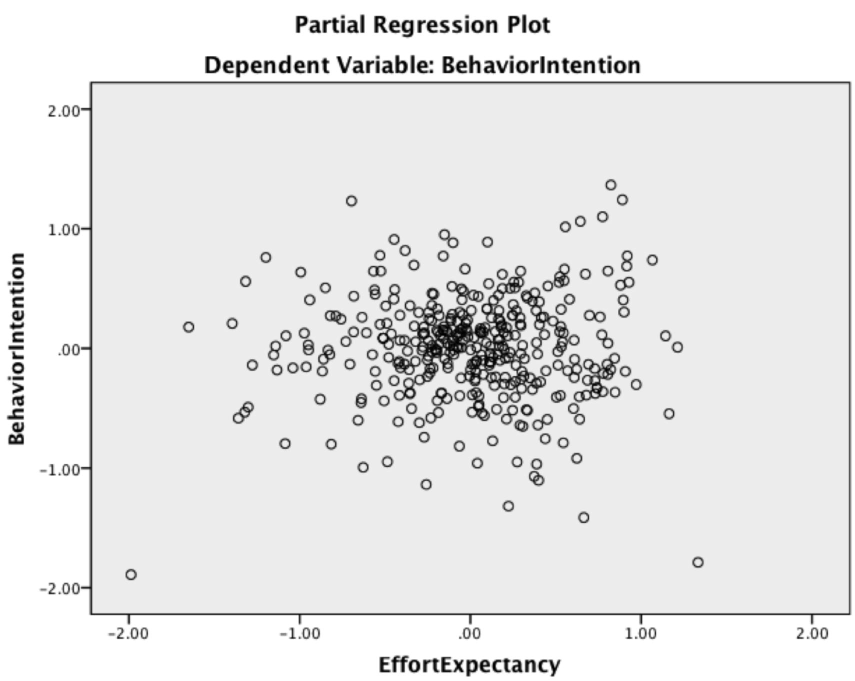

Figure F.10: Partial regression plot BI vs. EE

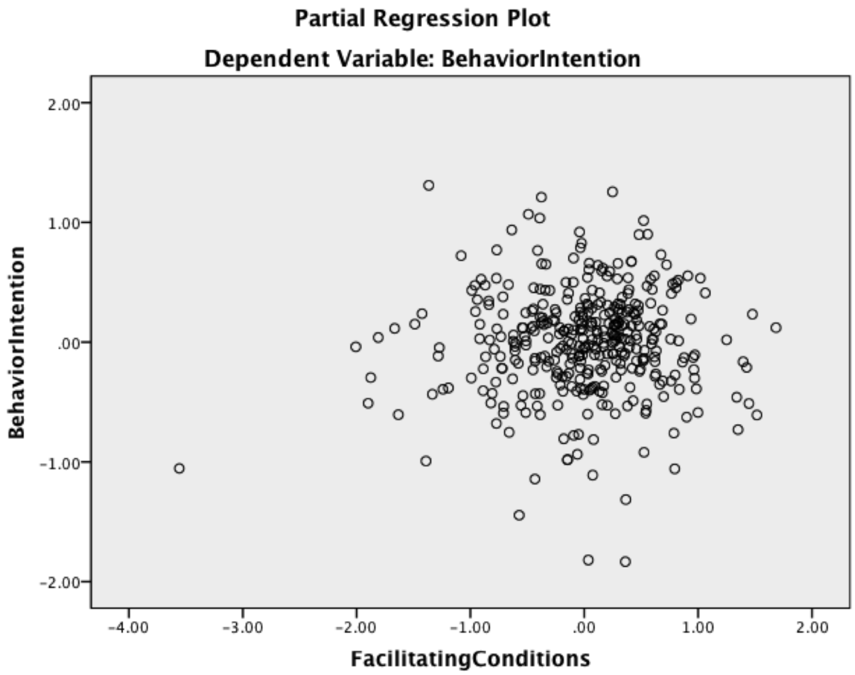

Figure F.11: Partial regression plot BI vs. FC

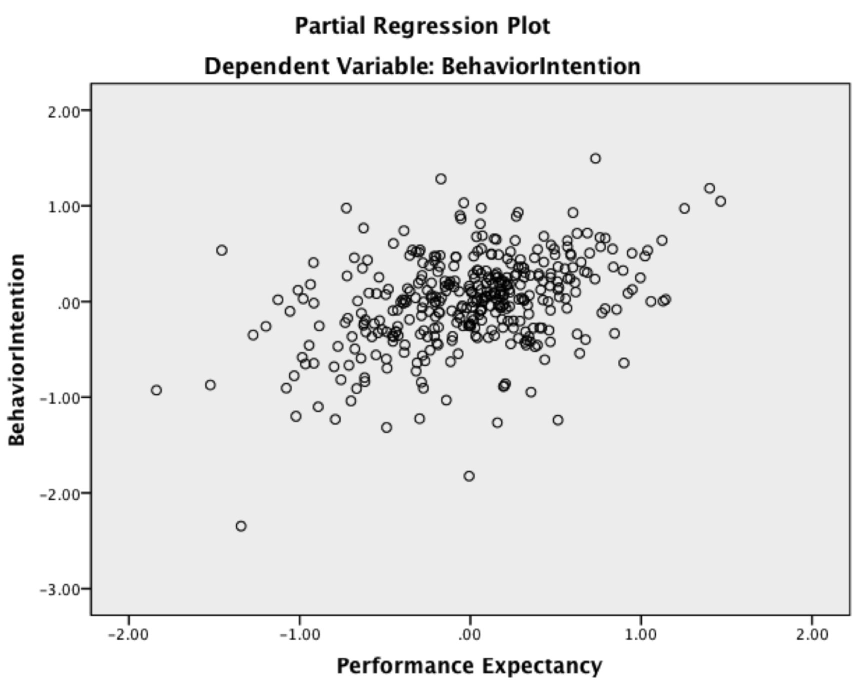

Figure F.12: Partial regression plot BI vs. PE

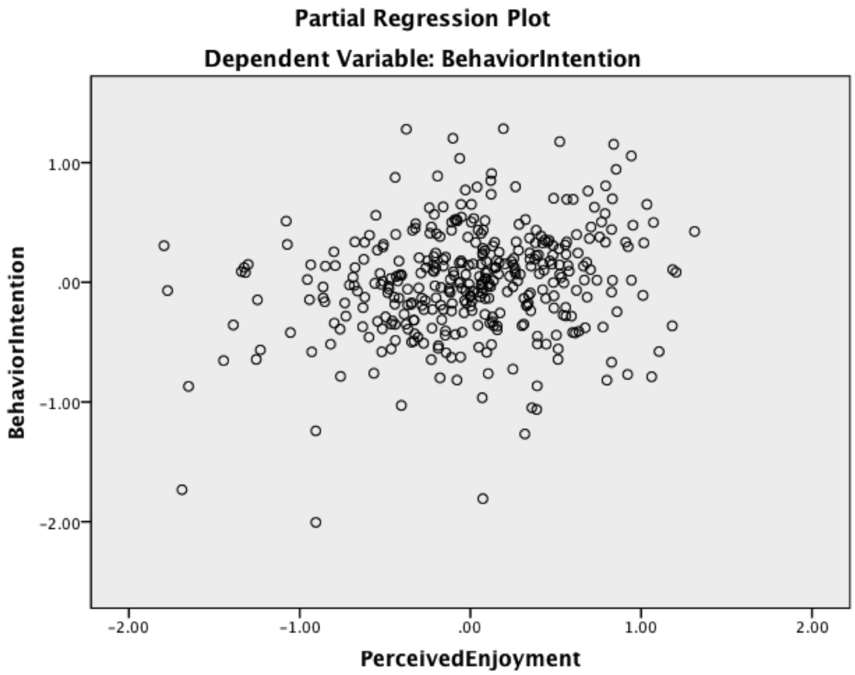

Figure F.13: Partial regression plot BI vs. PEn

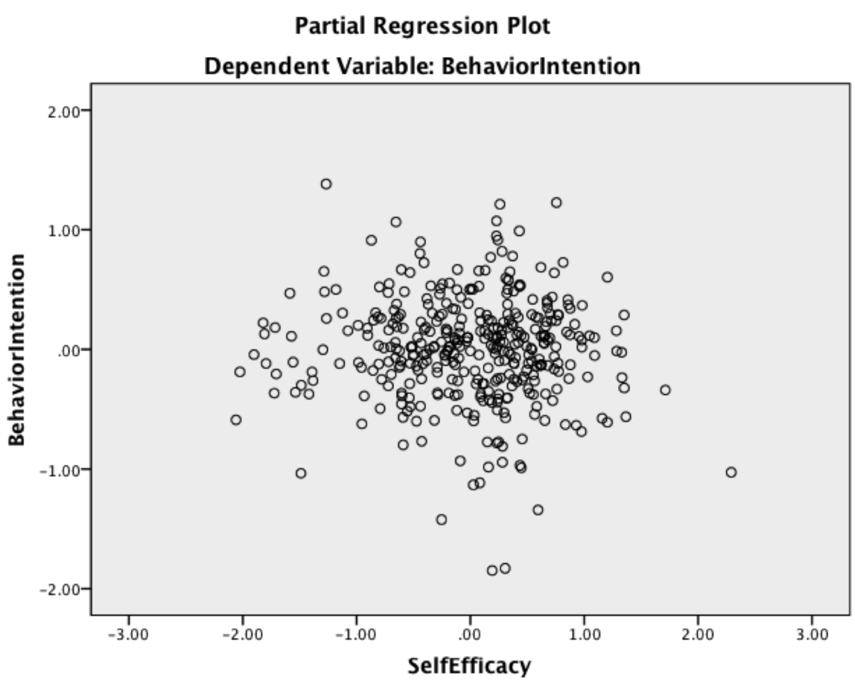

Figure F.14: Partial regression plot BI vs. SE

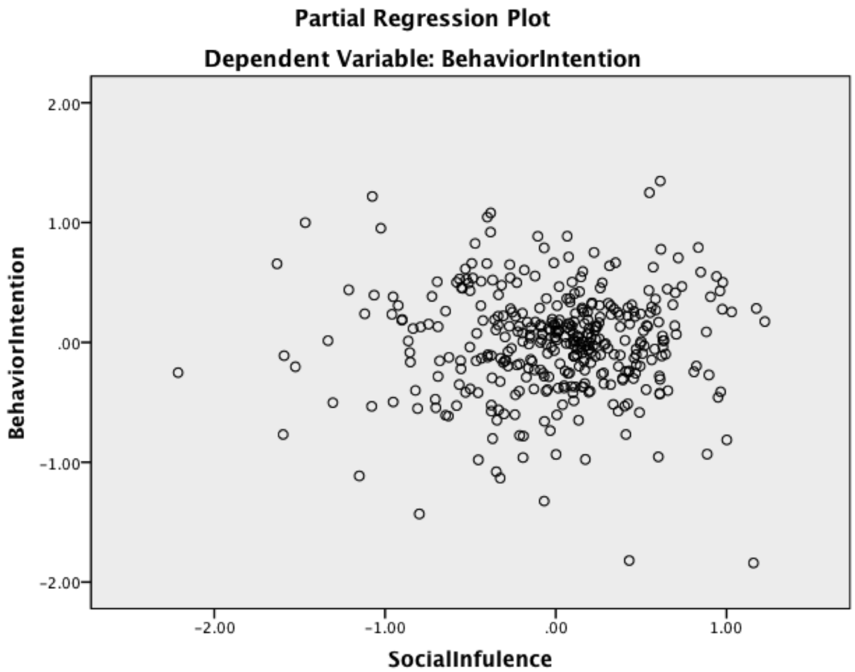

Figure F.15: Partial regression plot BI vs. SI

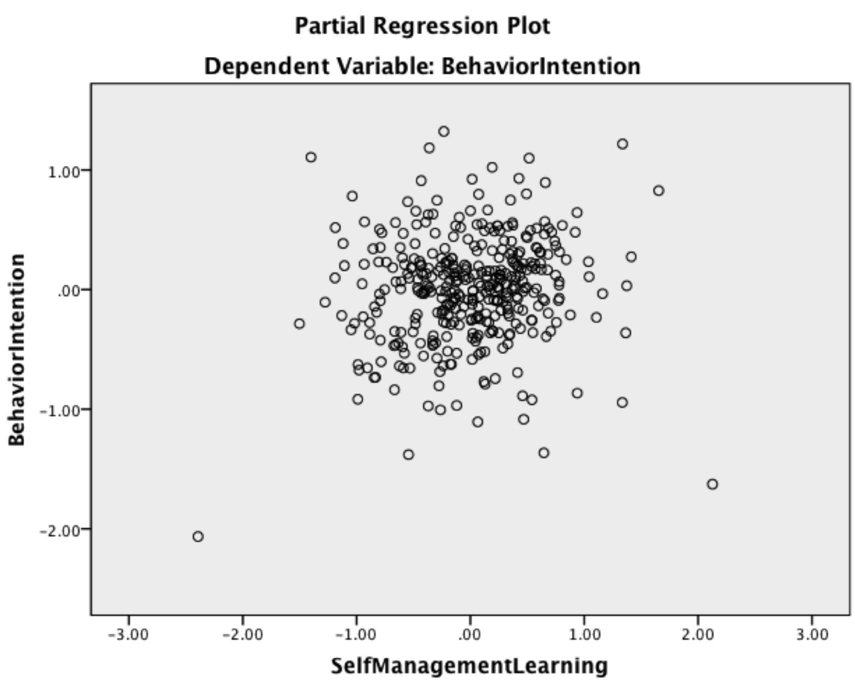

Figure F.16: Partial regression plot BI v.s. SML

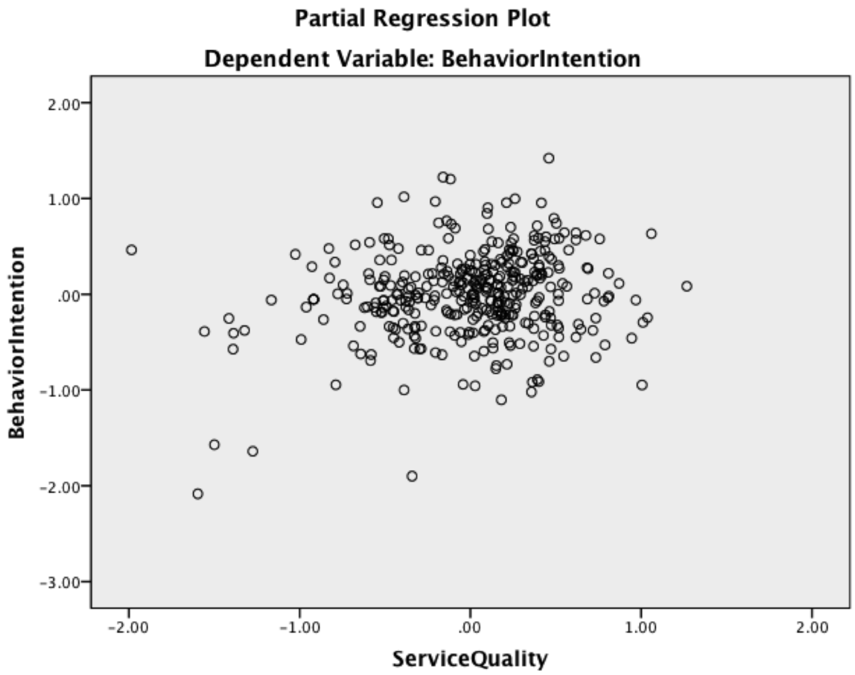

Figure F.17: Partial regression plot BI vs. SQ

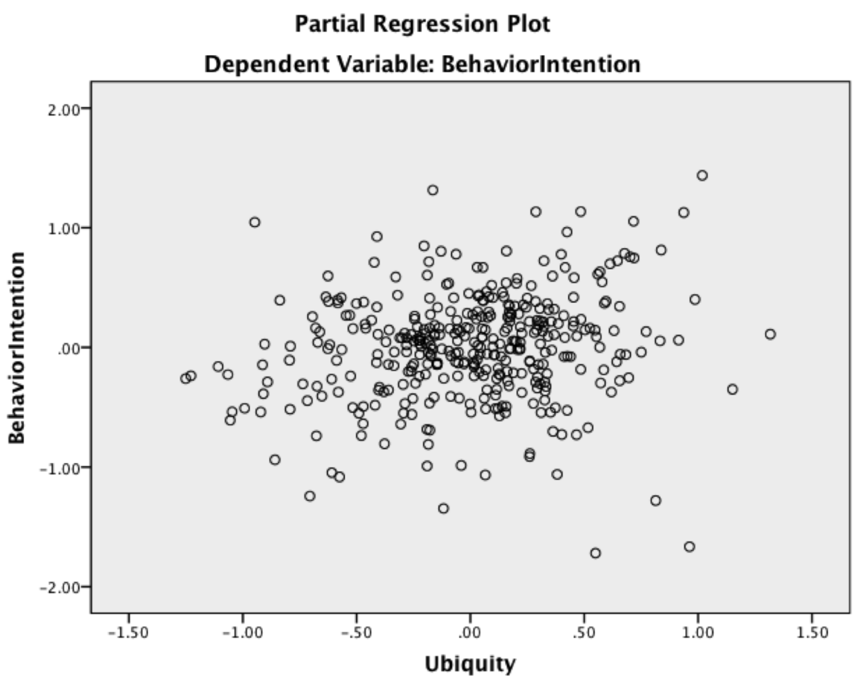

Figure F.18: Partial regression plot BI vs. Ubi

F.6 Stepwise Regression Analysis for Dependent Variable Behavior Intention

Table F.78: Model summary for stepwise regression analysis

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	ΔR^2	F Change	df1	df2	Sig. F Change
1	.763a	0.582	0.581	0.52607	0.582	522.472	1	375	0
2	.804b	0.647	0.645	0.48406	0.065	68.917	1	374	0
3	.827c	0.683	0.681	0.45923	0.036	42.543	1	373	0
4	.832d	0.693	0.689	0.45299	0.009	11.345	1	372	0.001
5	.838e	0.702	0.698	0.44673	0.009	11.489	1	371	0.001
6	.841f	0.707	0.702	0.44341	0.005	6.585	1	370	0.011

a Predictors: (Constant), PE
b Predictors: (Constant), PE, PEn
c Predictors: (Constant), PE, PEn, Ubi
d Predictors: (Constant), PE, PEn, Ubi, AV
e Predictors: (Constant), PE, PEn, Ubi, AV, SQ
f Predictors: (Constant), PE, PEn, Ubi, AV, SQ, SML

G Group Analysis

G.1 Device ownership between Groups

Table G.79: T-test of smartphone ownership vs. behavior intention

Group Statistics								
	Smartphone	N	M	SD	Std. Error Mean			
BI	No Yes	69 308	3.5314 3.9448	0.852 0.785	0.103 0.0445			
Independent Samples Test								
Levene's Test for Equality of Variances: F=1.308, p=0.254 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	-3.89	375	0	-0.413	0.106	-0.622	-0.204

Table G.80: T-test of PDA ownership vs. behavior intention

Group Statistics								
	PDA	N	Mean	Std. Deviation	Std. Error Mean			
BI	no yes	369 8	3.871 3.792	0.812 0.916	0.042 0.324			
Independent Samples Test								
Levene's Test for Equality of Variances: F=0.002, p=0.966 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	0.272	375	0.786	0.079	0.291	-0.493	0.651

Table G.81: T-test of tablet ownership vs. behavior intention

Group Statistics								
	Tablet	N	Mean	Std. Deviation	Std. Error Mean			
BI	no yes	220 157	3.749 4.038	0.888 0.661	0.060 0.053			
Independent Samples Test								
Levene's Test for Equality of Variances: F=10.154, p=0.002 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	-3.462	375.000	0.001	-0.290	0.084	-0.454	-0.125

Table G.82: T-test of MP3 or similar device ownership vs. behavior intention

Group Statistics								
	MP3 or similar device	N	Mean	Std. Deviation	Std. Error Mean			
BI	no	174	3.915	0.820	0.062			
	yes	203	3.830	0.806	0.057			
Independent Samples Test								
Levene's Test for Equality of Variances: F=0.013, p=0.909 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	1.009	375	0.314	0.085	0.084	-0.080	0.250

G.2 Planned Device Purchase between Groups

Table G.83: T-test of smartphone purchase vs. behavior intention

Group Statistics								
	Smartphone	N	Mean	Std. Deviation	Std. Error Mean			
BI	no yes	260 117	3.835 3.946	0.854 0.709	0.053 0.066			
Independent Samples Test								
Levene's Test for Equality of Variances: F=3.565, p=0.06 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	-1.23	375	0.219	-0.111	0.090	-0.289	0.067

Table G.84: T-test of tablet purchase vs. behavior intention

Group Statistics								
	Tablet	N	Mean	Std. Deviation	Std. Error Mean			
BI	no yes	265 112	3.777 4.086	0.829 0.732	0.051 0.069			
Independent Samples Test								
Levene's Test for Equality of Variances: F=1.759, p=0.186 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	-3.42	375	0.001	-0.309	0.090	-0.487	-0.131

Table G.85: T-test of MP3 or similar device purchase vs. behavior intention

Group Statistics								
	MP3 or similar device	N	Mean	Std. Deviation	Std. Error Mean			
BI	no yes	355 22	3.874 2.796	0.819 0.718	0.043 0.153			
Independent Samples Test								
Levene's Test for Equality of Variances, F=0.439, p=0.508 t-test for Equality of Means								
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower 95% CI of the Difference	Upper 95% CI of the Difference
BI	Equal variances assumed	0.438	375	0.662	0.078	0.179	-0.273	-0.430

G.3 Group Descriptives for ANOVA Tests

Table G.86: Descriptives by age

Behavior Intention	N	Mean	Std. Deviation	Std. Error	95% Lower C.I.for Mean	95% Upper C.I.for Mean	Min	Max
Under 18 years	1	4	.	.	.	.	4	4
18-22 years	229	3.917	0.837	0.055	3.808	4.026	1	5
23-26 years	75	3.727	0.775	0.090	3.548	3.905	1	5
Over 26 years	72	3.863	0.770	0.091	3.683	4.044	2	5
Total	377	3.869	0.813	0.042	3.787	3.951	1	5

Table G.87: Descriptives by college level

Behavior Intention	N	Mean	Std. Deviation	Std. Error	95% Lower C.I. for Mean	95% Upper C.I. for Mean	Min	Max
Freshmen	46	3.859	0.835	0.123	3.611	4.107	2.33	5
Sophomore	61	3.943	0.848	0.109	3.726	4.160	1	5
Junior	68	4.012	0.772	0.094	3.825	4.199	1.670	5
Senior	108	3.912	0.853	0.082	3.749	4.075	1	5
Graduate	94	3.674	0.738	0.076	3.523	3.825	1.17	5
Total	377	3.869	0.813	0.042	3.787	3.951	1	5

Table G.88: Descriptives by years of using mobile devices

Behavior Intention	N	Mean	Std. Deviation	Std. Error	95% Lower C.I. for Mean	95% Upper C.I. for Mean	Min	Max
Less than 1 year	37	3.919	0.658	0.108	3.700	4.138	2.330	5
2-3 years	102	3.796	0.884	0.088	3.622	3.969	1	5
4-6 years	119	3.864	0.804	0.074	3.718	4.010	1.670	5
More than 6 years	110	3.921	0.820	0.078	3.766	4.076	1	5
Total	368	3.868	0.817	0.043	3.784	3.952	1	5

Vita

Yu Huang was born in Jilin Province, China. She is the only daughter in her family. She attended the Wuhan University in China and obtained a Bachelor of Engineering degree in printing technology. After graduation, she headed to the University of Wisconsin-Stout in the United States where she studied human resources development. After successfully completing the program in the University of Wisconsin-Stout, she obtained a Master of Science degree. Later on, she applied for PhD program in the department of Industrial and Systems of University of Tennessee, Knoxville in 2009 and got accepted. She is now continuing her education with a doctorate degree of Industrial and Systems Engineering at the University of Tennessee, Knoxville.