

December 2006

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Recommended Citation

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AMCIS 2006 Proceedings. 268.

<http://aisel.aisnet.org/amcis2006/268>

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Using Mobile Technology in Education: Perspectives of Students and Instructors

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ABSTRACT

Mobile technology has the tremendous potential in supporting and improving education and its delivery. As a new phenomenon that is gaining popularity, the values of mobile technology in education need to be better researched and understood. In this research, we used the Value-Focused Thinking approach to interview students and instructors to identify the values of education that are enabled by mobile technology. These values are represented in the form of a means-ends objective network that not only captures the values of education facilitated by mobile technology but also depicts the relationships between these values. The values of education enabled by mobile technology support all four types of learning approaches – behaviorism, cognitivism, constructivism, and social constructivism, thus facilitating the different forms of learning and providing flexibility to students on their preferred way of learning. The means-ends objective network derived from this research can serve as a conceptual foundation for future studies and provides useful guidelines to practitioners for implementation of mobile technology in education.

Keywords

Mobile technology, value-focused thinking, means-ends objective networks, theories of learning

INTRODUCTION

Mobile technology has extended access for desktop-based online environment to handheld devices to support delivery of education at anytime and anywhere, which is sometimes called “mobile education” or “M-Education”. Mobile education can be defined as “using any service or facility to provide a learner with general electronic information and educational content that aids in the acquisition of knowledge regardless of location and time” (Lehner and Nosekabel, 2002). Continues and rapid advancement in mobile technology will undoubtedly accelerate the use of mobile devices in educational settings.

With its unique features and functions such as mobility, reachability, localization, and personalization, mobile technology shows a lot of promise in supporting and improving education. In an evaluation report by the Palm Education Pioneers Program, teachers’ evaluation of mobile technology (using handheld devices such as Palm computers) was overwhelmingly positively - 96.5% of them indicated that they believed handheld computers were effective instructional tools and 93% believed that handheld computers contributed positively to the quality of learning activities that their students completed in the semester (Crawford and Vahey, 2002).

Despite the tremendous potential of mobile technology in education, the application of mobile technology in education is still in the infancy stage. In order to extend current education related activities into the mobile context, it is important to understand their potential values to users. More importantly, we need to understand the benefits, problems and limitations of using mobile technology in educational settings, to unveil issues that are important for the adoption and diffusion of mobile education applications, and to provide suggestions and guidelines for future development of mobile education applications. We also need to gain a better understanding of how mobile technology can be used to facilitate and support students learning using different learning approaches.

LITERATURE REVIEW

Theories of Learning

Information technology can be used in educational settings to support different models of learning (Leidner and Jarvenpaa, 1995). We reviewed some of the widely adopted learning models to understand their implications on education. Four main theories of learning have been identified in the literature – behaviorism, cognitivism, constructivism, and social constructivism.

The traditional view of learning is represented by the behaviorism model which is derived from the stimulus and response theory of Skinner. It argues that learning is a change in the behavioral disposition of an organism that can be shaped through reinforcement (Jonassen, 1993). Employing this type of learning model, the function of the instructor is to provide stimulus to the students for them to learn, and students learn mainly through memorizing and responding (Hung, 2001).

From the perspective of cognitivism, learning refers to the processing and transfer of new knowledge into long-term memories. The mind is perceived as an information processor with short-term and long-term memories. Knowledge is a storehouse of representations (patterns) which can be called upon for use in reasoning and can be translated into language (Hung, 2001). Stimulus can be provided by instructors to improve recall and retention of knowledge. And instructors require feedback on students' learning.

The constructivist model of learning stresses that knowledge is created or constructed by each learner. It argues that learning is an active process of constructing rather than acquiring knowledge. Whatever gets into the mind has to be constructed by the individual through knowledge discovery with a focus on the process of assimilation and accommodation of knowledge. Individuals can learn better when they discover things themselves and when they control the pace of learning (Leinder and Jarvenpaa, 1995). The constructivist model of learning implies that learning must be learner-centered and instructors provide support rather than direction.

Social orientations of constructivism have gained wide popularity in recent years. The general view of social constructivism is that human knowledge is socially constructed, and the interpretation of knowledge is dependent on the social and cultural context through which the knowledge was constructed (Hung, 2001). For example, Vygotsky's (1978) sociocultural theory emphasizes the critical importance of interaction with people in learning and thinking.

Table 1 provides a table to summarize these theories of learning.

Theory	Key Concepts	Type of learning
Behaviorism	Stimulus and response	Memorizing and responding
Cognitivism	Processing and transmitting of knowledge	Memorizing and application
Constructivism	Discovery or construction of knowledge	Problem solving
Social constructivism	Social construction through interpersonal interaction	Collaborative learning and problem solving

Table 1: Theories of learning

Learning Process

Educational theorists and practitioners have drawn upon the work of psychologists to develop models for instructions that can promote learning. Mayers (1995), basing on research findings from cognitive psychology, argued that: (1) learning is a by-product of understanding; (2) understanding occurs best through performing tasks; and (3) learning is largely social in origin. Mayers (1995) then argued that learning is a circle of action, feedback, and reflection. He emphasized the need to put new information into new context for the learner to apply it in practice and he believed that discussion with fellow learners and instructors can promote the process of feedback and reflection.

Alavi (1994) identified three attributes of effective learning process: (1) Active learning and construction of knowledge. Learning is best accomplished by actively involving students in construction of knowledge and understanding through acquisition, generation, analysis, and manipulation of information. (2) Cooperation and teamwork in learning. Learning can be viewed as a social process that could occur more effectively through cooperative interpersonal interactions. (3) Learning

through problem solving. Knowledge of specific domains or strategies of solving problems can be acquired through the process of problem solving.

UNDERSTANDING MOBILE LEARNING ENVIRONMENT

The use of mobile technology in education can revolutionize the processes of learning and teaching, and changed the learning environment. Some of the unique characteristics of mobile learning environment are described as follows (Chen *et al.*, 2002):

Initiative of knowledge acquisition. The information provided through mobile technology is based on the learner's request, that is, it is information on-demand. Based on the learner's needs, mobile devices and mobile technology can enable real-time display of information.

Mobility of learning settings. Mobile devices are portable, which allow the users to carry them around. Therefore, learning practices can take place at anytime and anywhere, such as on the road, at home, or at a coffee shop. Mobile devices can also facilitate data collection and information retrieval during field trips.

Interactivity of learning process. Through portable mobile devices and multi-media functions provided by the devices, students can communicate and interact with peer students, instructors, and experts more readily and effectively. Therefore, expert knowledge and opinion can be more readily accessible, and educational resources and instructions are more readily available.

Integration of instructional content. Mobile technology enables students to have access to a variety of information and resources more readily and provide support for more complex learning activities by students.

Therefore, applications of mobile technology can facilitate teaching and learning in a more dynamic and complex learning environment. In this research, our objectives are: (i) to provide an empirical assessment of the values and potential of mobile technology in education, and (ii) to provide a better understanding of the values of mobile education using the theories of learning.

RESEARCH METHODOLOGY

The Value Focused Thinking approach (VFT) (Keeney, 1992) provides a systematic way to identify values and organize the values. The VFT approach, which is fundamentally about deciding what is important and how to achieve it, defines essentially what the decision maker cares about (Keeney, 1992). It is very helpful for identifying values and objectives that are usually hidden. Values are *principles* used for evaluation by customers/users (Keeney, 1992). Values that are of concern are made explicit by the identification of objectives. An objective is a statement of something that one desires to achieve (Keeney, 1992). An objective is characterized by three features: a decision context, an object, and a direction of preference. VFT not only uncovers hidden objectives, but also provides a systematic way of identifying relationships among objectives. The VFT approach is, therefore, well suited for the purpose of this study.

The steps of VFT are as follows (see figure 1):

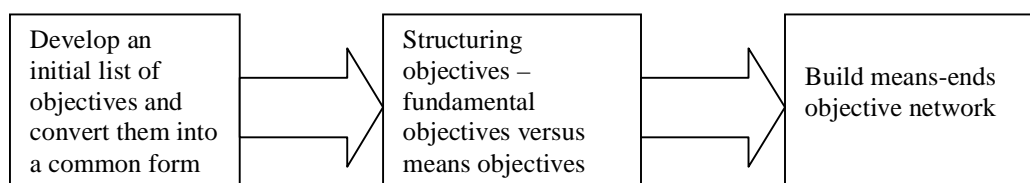


Figure 1: Steps involved in Value-Focused Thinking

(1) Develop an initial list of objectives and convert them into a common form. Several popular techniques that can help stimulate the identification of possible objectives include “wish list”, problems and shortcomings, alternatives, and consequences (Keeney, 1992). Probing questions include:

“What are the benefits of using mobile technology in education?”

“What problems or concerns can arise in mobile education?”

“If there is no limitation at all, what are the features or functions of mobile technology you wish to have?”

From the interviews, a list of values that are relevant to mobile education are collected and converted into objectives (i.e., expressed them in the format of ‘objectives’) which are common forms for each set of related values.

(2) Structuring objectives – fundamental objectives versus means objectives. After collecting the list of objectives, this step distinguishes between fundamental objectives and means objectives. Fundamental objectives concern “the ends that decision makers value in a specific context” whereas means objectives are “methods to achieve ends” (Keeney, 1992). To separate means objectives from fundamental objectives and to establish their relationships, Keeney (1992) suggested using the “Why Is That Important?” test. For each identified objective, asking “Why Is That Important?” (WITI) yields two types of possible responses. One is that this objective is one of the essential reasons for interest in the situation and is fundamental for decision making. This is called a *fundamental* objective. The other response is that an objective is important because of its implication for some other objective(s). This is called a *means* objective.

(3) Building means-ends objective network. The final step in the VFT approach is to build the means-ends objective network. This network provides a model of the specific interrelationships among the means objectives and their relationships with fundamental objectives. The relationships depicted in the model allow analysts to better understand and comprehend the decision maker’s value system, and to select alternatives that are designed to achieve these fundamental objectives via their effects on the means objectives.

RESEARCH RESULTS

Subjects

Using the Value-Focused Thinking approach, we interviewed a total of 33 subjects regarding the values of mobile technology in education. Among the 33 subjects, 18 of them were university students and 15 of them were instructors at a large Midwestern university. All subjects owned mobile devices and had used mobile devices for at least a year; hence, they have the necessary understanding of mobile technology and its implications for education. The interviews were conducted face-to-face using the Value-Focused Thinking approach; each interview lasted approximately 30-45 minutes.

Deriving Fundamental and Means Objectives

After interviewing the 33 subjects, we derived a list of fundamental objectives as well as means objectives (see Table 2). A means-ends objective network was constructed to depict the objectives and relationships between objectives (see Figure 2).

Fundamental Objectives:

Overall Objective: Maximize Values of Education Using Mobile Technology

Maximize convenience of education

Example: Maximize time flexibility in educational activities
Minimize location-specific constraints for education

Maximize effectiveness in learning

Example: Maximize acquisition of knowledge
Maximize understanding of education materials

Maximize individual privacy

Example: Prevent invasion of personal life
Ensure private space of instructors

Ensure academic honesty

Example: Minimize opportunities for dishonest conduct
Prevent plagiarism in educational activities

Maximize efficiency in learning

Example: Accelerate learning procedures
Maximize time management

Maximize usability of mobile education services

Example: Maximize ease of use of mobile education services
Maximize ease of navigation on mobile education websites

Minimize cost of education

Example: Minimize need to commute to campus
Reduce cost of education through virtual learning

Maximize security of student/instructor information

Example: Maximize confidentiality of personal information
Maximize confidentiality of students’ performance (e.g., grade)

Means Objectives:

Maximize coverage area of wireless services

Example: Maximize wireless access points
Maximize area of coverage

Maximize mobility of mobile devices

Example: Maximize portability of mobile devices
Mobile devices work at any place or condition

Maximize education on demand

Example: Ability to access course materials from any place
Education is not constrained to locations

Maximize information/idea sharing

Example: Maximize info. exchange with students/instructors
Maximize ability to beam data/ideas to team members

Enable virtual meetings

Example: Enable virtual classroom meetings via mobile devices
Enable virtual study groups

Maximize tracking of education activities

Example: Availability of To-Do list
Ability to track work done by team members

Maximize organization of education activities

Example: Provide project management features for education
Ability to plan education activities

Enable mobile-testing

Example: Students can take test on mobile devices at any time
Students can take self-assessment test from any place

Maximize multi-media capabilities of mobile devices

Example: Maximize the availability of multi-media functions on mobile devices
Maximize the use of video and audio conferencing

Maximize immediate feedback

Example: Maximize students' ability to get immediate answer
Maximize instructors' ability to offer real-time question/answering

Maximize enjoyment of learning

Example: Learning should be fun
Mobile education should make learning enjoyable

Minimize distraction of mobile devices in classroom

Example: Minimize interruption from mobile devices
Ability to block distractions (e.g., beaming, instant messaging)

Maximize accessibility of mobile education services

Example: Maximize access to mobile education services at any time
Maximize access to mobile education services while on the move

Maximize availability of education resources

Example: Maximize access to educational websites via wireless Internet
Maximize availability of information from the field

Maximize customized learning

Example: Students can learn at their own pace
Provide personalized learning materials

Maximize virtual collaboration among students

Example: Maximize collaborative learning among students
Maximize collaboration support for project teams

Maximize flexibility in teamwork/meeting

Example: Teams need not meet face-to-face
Ability to carry out asynchronous meetings

Maximize scheduling of education activities

Example: Availability of scheduling features for mobile education
Ability to check team members' availability for scheduling meeting

Maximize availability of instructors

Example: Instructors are more readily available to students
Instructors can be accessed outside classroom

Increase bandwidth of mobile services

Example: Increase bandwidth of downloading course material
Increase bandwidth of wireless services

Maximize interaction in education

Example: Improve interaction between students and instructors
Improve interaction among students

Enable capturing of information from the field

Example: Ability to take pictures during field trip
Ability to video tape sessions

Maximize student involvement in learning

Example: Maximize students' participation in learning
Maximize students' engagement in learning

Enhance user-interface of mobile devices

Example: Improve input mechanism of mobile devices
Enlarge screen size of mobile devices

from mobile devices in classroom

Maximize ease of use of mobile education devices

Example: Maximize ease of input

Maximize ease of navigation

Maximize security features of wireless services

Example: Maximize encryption of data

Ensure authentication of students

Minimize cost of wireless services

Example: Minimize cost of wireless Internet access

Minimize cost of monthly service fees

Maximize readability of display

Example: Enhance screen resolution

Use legible font size

Minimize cost of mobile devices

Example: Minimize cost of purchasing mobile devices

Ensure mobile devices are affordable

Prevent cheating with mobile devices

Example: Disable beaming during exam

Prevent plagiarism using mobile devices

Table 2: Fundamental objectives and means objectives

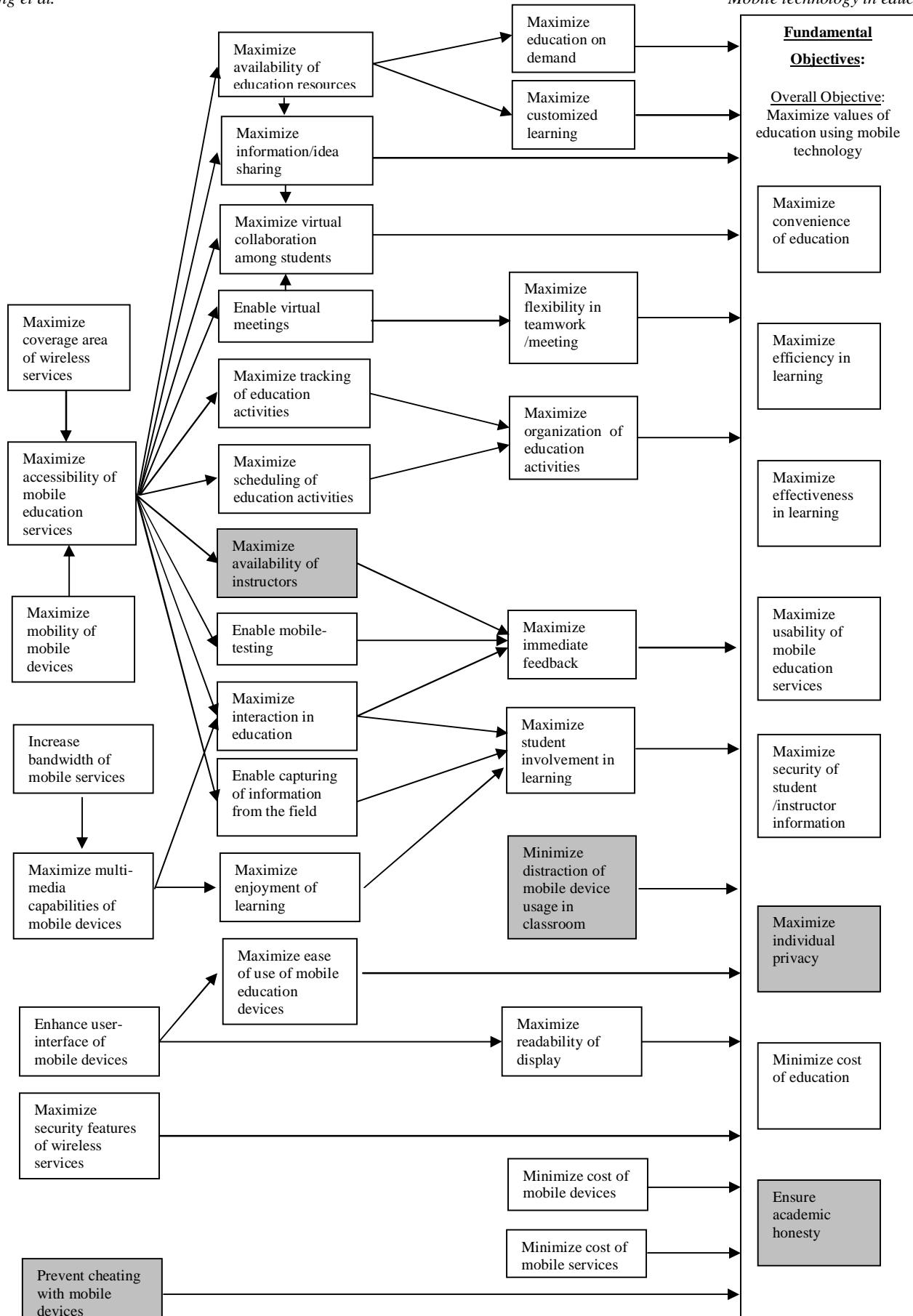


Figure 2: Means-ends Objective Network

DISCUSSIONS AND IMPLICATIONS

Fundamental Objectives and Means Objectives

The overall objective for mobile applications and technology in education is to maximize the values of education. We identified eight fundamental objectives identified in this study – maximize convenience of education, maximize efficiency in learning, maximize effectiveness in learning, maximize usability of mobile education services, maximize security of student/instructor information, maximize individual privacy, minimize cost of education, and ensure academic honesty. These eight objectives represent the fundamental values of mobile applications in education from the students' and instructors' perspectives and determine the “principles” (Keeney, 1992) for assessments concerning the use of mobile technology for education. These objectives are the fundamental reasons that drive mobile application development for education purposes.

The goals of education are to increase student knowledge and students' ability to acquire new knowledge. Therefore, it is reasonable that the fundamental objectives for using mobile technology to support education include “*effectiveness*” (Can mobile technology produce better learning outcomes than traditional education?) and “*efficiency*” (Can mobile technology expedite the learning process?). Nevertheless, mobile technology provides new means to achieve “effectiveness” and “efficiency” by utilizing features and functions available through mobile technology in learning environment. For example, mobile technology enables students to access educational materials at anytime and anyplace, which increases the availability of educational resources. This, in turn, makes it possible to provide educational resources based on students' personal needs and demands. These means objectives lead to an increase in the effectiveness of learning. Mobile technology also enables mobile-testing, which can result in immediate feedback, and hence, improve “efficiency” in learning.

“*Convenience*”, as stated by subjects during the interviews, is one of the key advantages of using mobile technology for education. This advantage is primarily derived from the mobility features of mobile devices and the “anytime and anywhere” ability of wireless services. For instance, “anytime and anywhere” access allows students to hold virtual meetings with other students to carry out group assignments or projects, or to hold virtual discussions with instructors, thereby, increasing flexibility in teamwork and meetings (i.e., resolving problems of time conflict and eliminating location constraints). This increased flexibility makes it more convenient for students to carry out group projects and to interact with instructors more frequently.

“*Usability*” arises as a fundamental objective because of the limitations of mobile devices. Current mobile devices have far from ideal user interface, which makes it difficult to use and navigate, and this affects the readability of information display. Therefore, research and developments must be undertaken to improve usability and user-friendliness of mobile devices.

“*Security*” is important for mobile education where information is transferred through the wireless medium, which is perceived to be more vulnerable to hacking or interception. The subjects in our study felt that more and better security features must be provided, such as encryption and authentication.

“*Individual privacy*” must be ensured when mobile technology is used in educational settings. The “anytime, anywhere” accessibility of mobile technology makes instructors more readily available and reachable, which, in turn, might invade instructors' private time or space.

“*Cost*” refers to the cost of mobile devices and services. Although mobile devices are considerably cheaper than desktop computers, monthly fee must be paid in order to have access to the Internet from these mobile devices. For mobile technology to be widely employed in education, the subjects stressed that cost is an issue that must be taken into account.

“*Ensure academic honesty*” is another fundamental objective of mobile education. Students can use mobile devices to beam information during an exam or plagiarize by copying from Internet resources more easily. Although mobile technology has the potential to transform education, academic honesty must be ensured.

The means objectives derived from this study as well as the relationships between them illustrate how the fundamental objectives can be achieved. The means objectives not only include features or functions of mobile technology, but they also highlight possible mobile applications for education. Based on the means objectives derived, we identified the following ways where mobile technology can contribute to education:

- I. *Maximize education on demand.* With the ability to access educational materials at anytime and anyplace, mobile technology makes educational resources more accessible. Therefore, students can gain access to the educational resources based on their personal needs. Since the availability of educational resources are not constrained or confined to certain places at certain time (as in the case of traditional learning), knowledge acquisition can be facilitated based on the learners' needs and requests (Chen et al., 2002).

- II. *Maximize customized learning.* Educational resources can be tailored based on the students' personal preferences or abilities. Educational materials can be provided to the students at the appropriate level and students can learn those materials at their own pace.
- III. *Maximize virtual collaboration among students.* Virtual meetings through mobile devices and wireless services provide new means for student collaboration. Students can attend virtual classes using their mobile devices or form virtual study groups with peer students. Mobile technology allows students to collaborate with peer students with less time and location constraints.
- IV. *Maximize organization of education activities.* Mobile devices usually have "personal digital assistant" functions which include scheduling, to-do list, and tracking. These functions make it easier for students and instructors to keep up with educational activities such as meetings and assignments, and help them to be more organized.
- V. *Maximize immediate feedback.* Mobile testing or quizzes allow students to take tests using mobile devices to assess their understanding of the course materials. Software applications can evaluate and analyze students' performance, and provide feedback immediately to both instructors and students. Also, enhanced interaction using mobile technology enables students to ask instructors questions whenever the need arises (such as when they encounter a problem) and to get instantaneous feedback from instructors.
- VI. *Maximize student involvement in learning.* Students' participation and engagement are very important for effective and efficient learning. Mobile technology provides faster and more frequent interactions between students and educators, thereby, increasing students' willingness to participate and engage in learning. This idea is in line with the "interactivity of learning process" feature of mobile learning environment suggested by Chen et al. (2002).

Differences between Students and Instructors

In this study, we identified a list of objectives and developed a means-ends objective network that depicts the objectives and the relationships between them. Interestingly, the objectives identified by students and by instructors are similar. Both sets are driven by the purpose of education, which is to facilitate students' learning. Learning is a process that involves knowledge transfer from instructors to students (i.e., the views of behaviorism and cognitivism), and it also involves discovery and construction of knowledge through interactions with peer students and with instructors (i.e., the views of constructivism and social constructivism). Therefore, students and instructors are two integrated parties in education; each party views the values of education by taking into account the other party.

Although the aggregated values of mobile education are the same for both students and instructors, the qualitative nature of this study yields very rich, in-depth, and narrative data that implicates some differences between students and instructors in terms of their emphasis of some objectives. Both students and instructors highlighted the potential of mobile technology in education; instructors, though, are more concerned about potential problems of using mobile technology in educational settings. The grayed boxes in the means-ends objective network (see figure 1) highlight the instructors' concerns.

"*Individual privacy*" has been expressed by many instructors during the interviews. Because of the mobility features of mobile technology, instructors can be reached anytime, anywhere, and will become more available to students. Although this *increased availability* provides greater opportunity for real-time interactions between students and instructors, it might, at the same time, invade instructors' private time and space, which may affect instructors' personal life.

"*Academic honesty*" is another concern raised by instructors concerning using mobile technology in educational settings. When students are equipped with mobile devices that can provide them instant access to educational resources, inappropriate use of mobile technology can damage academic honesty; for example, students may use mobile devices to beam information during exams. Instructors, therefore, want to make sure that mobile technology is used appropriately in educational settings.

The use of mobile devices in the classroom can possibly distract students' attention during lectures. The "*distractions*" caused by using mobile devices in the classroom poses challenges in classroom management by instructors.

These objectives, though also mentioned by students during interviews, did not receive as much attention from students. Students are more focused on the benefits that mobile technology can bring to them. Some possible explanations for these differences include: (1) instructors are responsible for managing and monitoring the education process; and (2) instructors are more concerned about personal time and space.

Understanding values of mobile education from theoretical perspectives

As mentioned earlier, the use of information technology in educational settings reflects some forms of learning models that influence the process of learning. The values of mobile technology in education can map into the different learning models and the process of learning.

From the perspective of behaviorism, learning is a process of stimulus and response, and knowledge can be achieved through memorizing and responding. Mobile technology makes educational materials more readily available and hence, students can study those materials anytime and anywhere. Instructors can utilize the multi-media functions of mobile devices to facilitate the delivery of education content, thus, making them more interesting and easier for students to remember.

From the viewpoint of cognitivism, learning involves processing and transferring knowledge into long-term memories. Mobile technology can facilitate this type of learning by making educational resources more readily available, making instructors more available, enabling students to get immediate feedback from instructors and peer students, and providing opportunities for students to apply knowledge learned in the field.

Constructivism focuses on the discovery and construction of knowledge by students alone. Mobile technology can enable “education on demand” and “customized learning” which is learner-centered and allows students to learn at their own pace. The greater availability of educational resources provides greater opportunity for students to “discover” new knowledge and to “construct” knowledge.

Mobile technology has the strongest implications for social constructivism method of learning. As social constructivism views knowledge as being constructed in the social and cultural context, interpersonal interactions are very important. Mobile technology provides more opportunity for students to interact with instructors, as well as among students. Mobile technology can also facilitate collaborative learning by providing various means of communications such as virtual meetings and instant messaging. Students can work on group assignments or team projects together in a more flexible and efficient way.

Table 3 provides mappings between the key means objectives and the different learning theories.

	Behaviorism	Cognitivism	Constructivism	Social constructivism
Maximize accessibility of educational services	X	X	X	
Maximize availability of educational resources	X	X	X	
Maximize availability of instructors	X	X		X
Maximize immediate feedback	X	X		X
Enable mobile testing	X	X		
Enable capturing of information from the field		X	X	
Maximize education on demand			X	
Maximize customized learning			X	
Maximize student involvement			X	X
Maximize information/idea sharing				X
Maximize virtual collaboration				X
Enable virtual meetings				X
Maximize interaction in education				X

Table 3: Mappings between means objectives and learning theories

Mobile technology also impact on the learning process in a number of ways. Learning is considered to be cycles of action, feedback, and reflection (Mayers, 1995) - mobile technology hastens these cycles by providing immediate feedback from

instructors, and enabling virtual meetings with peer students and instructors, as well as facilitating virtual collaboration among peer students.

Mobile education also satisfies the attributes of effective learning process identified by Alavi (1994): (1) it enables active learning – students can learn at anytime, anyplace; (2) it facilitates cooperation and teamwork – it provides functions such as virtual meetings and virtual collaboration; and (3) it improves learning through problem solving – through facilitation of team project or group assignment or the capability to capture data or information from the field.

CONCLUSIONS

This research elicits the values of mobile technology in education using the Value-Focused Thinking approach from both students and instructors' perspectives. This research is of significance to both academic researchers and industry practitioners. The value model (i.e., means-ends network) derived from this research can serve as a conceptual foundation for future research in mobile education. This research is of immense interest to practitioners and educators – as it provides directions for improving education and highlights potential areas for mobile application development.

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