Instructional Design Principles for Mobile Learning

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Eun-Ok Baek and Qi Guo

Contents

Abstract

With the exponential development of mobile devices and technologies, mobile learning has been in great use in higher education. This chapter will discuss the

E.-O. Baek (✉) · Q. Guo
College of Education, California State University San Bernardino, San Bernardino, CA, USA
e-mail: ebaek@csusb.edu; eyda.guo@gmail.com

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opportunities and challenges of mobile learning in higher education and review existing literature related to the design principles and frameworks for m-learning. Finally, this chapter will recommend comprehensive design principles with examples of mobile apps that closely applied the design principles.

1 Introduction

The number of mobile phone users worldwide in 2017 was expected to reach 4.7 billion, over 63% of the world's population (The Statistics Portal 2017).

Steadily, new technology functions are adding to mobile phone markets. Mobile phones serve not only as telephones but also as minicomputers, video and still cameras, PDA's, audio recorders, GPS navigators, and smart and integrated Internet of Things using apps. The lightweight mobile technologies have opened a new horizon of disruptive technology within education. However, it also allows students to be engaged in ubiquitous formal and informal learning environments because students can access learning environments anytime and anywhere. This learning is referred to as mobile learning or m-learning (Dyson et al. 2009).

There are different definitions of mobile learning. Specifically, for a higher education landscape, El-Hussein and Cronje (2010) define mobile learning as "any type of learning that takes place in learning environments and spaces that take account of the mobility of technology, mobility of learners and mobility of learning" (p. 20). The mobility of technology refers to functionality of further advanced smart telephones and wireless technology that allow dynamic content delivery for learning. The mobility of learners means that learners are not bounded by a physical location and time but can learn at any place and at any time. The mobility of learning signifies the capacity for supporting personalized, situated, and ubiquitous learning activities.

Educational researchers and practitioners will need to deepen their insights into the best ways of developing and utilizing mobile learning. However, there is still only very limited research on the design principles that guide the effective design and development of m-learning which can harness the potential of mobile technologies and services.

Thus, this chapter will discuss the opportunities and challenges of mobile learning in higher education and review existing literature related to the design principles and frameworks for m-learning. Finally, this chapter will recommend comprehensive design principles with examples of mobile apps that closely apply the design principles.

2 Opportunities of Mobile Learning

Mobile learning has supported both individual and collaborative learning by expanding the definition of formal learning as well as allowing some learning to be informal (Gikas and Grant 2013). Specifically, mobile learning has

provided increased accessibility to learning, addressed differentiated learning, and enhanced student retention and achievement (Fozdar and Kumar 2007; Kukulska-Hulme et al. 2009).

2.1 Learning Anytime and Everywhere

"Learning anytime and everywhere" is the guiding statement adopted at by MLearn 2004, the international conference on mobile learning (El-Hussein and Cronje 2010). Mobile learning eliminates boundaries of time and geographical distance at the hands of learners (Awadhiya and Miglani 2016). When it is deployed strategically, mobile learning is an extension of e-learning and can generate added value to existing e-learning venues (Wang et al. 2009).

M-learning reaches the otherwise unreachable. Learners can access course materials, take quizzes, participate in synchronous and asynchronous discussions, submit assignments and receive feedback all from a single device at their fingertips (Awadhiya and Miglani 2016; Cheon et al. 2012; Hashemi et al. 2011).

2.2 Differentiated Learning and Personalized Learning

Mobile learning has offered differentiated and personalized learning. Looi et al. (2009) suggest four ways that mobile learning facilitates personalized learning: "(a) allowing multiple entry points and learning pathways, (b) supporting multimodality, (c) enabling student improvisation in situ, and (d) supporting the sharing and creation of student artifacts on the move" (p. 1120). Even though this study was conducted at an elementary school, their findings resonant within higher education contexts.

3G and 4G networks enable the simultaneous use of talking and data services (Wang et al. 2009; Wang and Shen 2012). This will greatly be speeded up with upcoming 5G network. Educators can design course materials targeting multiple modalities for their courses using rich media. Students can choose a type of course material that best fits their own learning modalities. Along the same line, rich media offer diverse ways to support student interaction.

2.3 Enhancing Student Retention and Achievement

Many studies argue that mobile learning enhances student satisfaction, which results in higher retention and achievement rates in students (Fozdar and Kumar 2007; Hashemi et al. 2011; Wang et al. 2009). M-learning also increases students' completion rate of courses. Hashemi et al. (2011) stated that newer mobile devices tended to increase learners' engagement and motivation.

In spite of the aforementioned potential of mobile learning, it has not been deployed to its fullest due to various challenging factors.

3 Challenge of Mobile Learning in Higher Education

Opportunities and challenges are like two sides of a coin. While there are many opportunities that mobile learning offers (as discussed in the previous section), mobile learning also presents many challenges in education.

3.1 Technical Challenges

Mobile phones are relatively inexpensive, and many learners own them. However, mobile phones become obsolete quickly due to rapid advancements in mobile technology (Hashemi et al. 2011). Wang and Shen (2012) argue that it is also the wide range of mobile devices used in learning which results in mobile learning design challenges. In addition, 3G and 4G networks are expensive to build and maintain, and services are, at the time of this writing, not widely available outside of urban environments (Wang and Shen 2012).

3.2 Lack of Support for Instructional Design, Institutional Policy, and Infrastructure

While the readiness of learners to adopt mobile learning is high, few instructors have successfully implemented mobile learning (Blackwell et al. 2014; Lauricella et al. 2017). This is largely due to faculty's lack of training, as well as their own internal and external pedagogical reasons (Ertmer et al. 2012). On the top of these, in a survey study conducted by Awadhiya and Miglani (2016) in universities in India, instructors selected "lack of support for instructional design for mobile learning," "lack of institutional policy for mobile learning," and "lack of infrastructure/technological support" as the top three challenges to implementing mobile learning. These findings confirm Panda and Mishra's research (2007) about the important difficulties instructors encounter at open universities.

The instructors' insufficient training, knowledge about, and skills with mobile learning are listed as the important roadblocks for technology integration – as evidenced in previous research.

4 Review of Design Guidelines and Frameworks for Mobile Learning

The authors thoroughly reviewed academic articles and research regarding design principles of mobile learning. They selected ten articles and research which discuss design guidelines for mobile learning. These selected articles and research were classified by a framework with the following five categories: (1) pedagogies and educational theories, (2) platform and system design, (3) technology acceptance,

(4) evaluation, and (5) motivation and interaction. This framework is suggested by Hsu and Ching (2015). As most of the articles contain principles that fall in more than one category, the authors analyzed and categorized the main goals and characteristics of the articles.

Category	Author	Title	Year	Principle/framework/module
Pedagogies and educational theories	Jalil, Beer, and Crowther	Pedagogical Requirements for Mobile Learning: A Review on MOBIlearn Task Model	2015	Address pedagogical requirements of mobile learning
	Dillard	Mobile Instructional Design Principles for Adult Learners	2012	A guide of mobile learning principles to instructional designers
	Herrington, Herrington, and Mantei	Design Principles for Mobile Learning	2009	The principles generated from New Technologies, and New Pedagogies Project that create and evaluate mobile pedagogies
	Mayer	Ten Research-Based Principles of Multimedia Learning	2006	The multimedia learning principles that stem from Cognitive Loading Theory
Platform and system design	Elias	Universal Instructional Design Principles for Mobile Learning	2011	Apply the UID principles to facilitate the design of instructional and operating systems of mobile learning materials
	Hockly	Mobile Learning	2013	The SAMR Model for using technology to design mobile learning activities for ELT
Technology acceptance	Wang and Shen	Message Design for Mobile Learning: Learning Theories, Human Cognition and Design Principles	2012	Principles and processes of m-learning message design
	Levene and Seabury	Evaluation of Mobile Learning: Current Research and Implications for Instructional Designers	2015	An adapted conceptual framework, which combines the Framework for the Rational Analysis of Mobile Education (FRAME) and Transactional Distance Theory (TDT)
Evaluation	Motiwalla	Mobile Learning: A Framework and Evaluation	2007	A m-learning system was developed to evaluate students' perception of m-learning
Motivation and interaction	Menkhoff and Bengtsson	Engaging Students in Higher Education Through Mobile Learning: Lessons Learnt in a Chinese Entrepreneurship Course	2012	A case study indicated that engagement mobile tool enables students in a meaningful and exciting classroom

4.1 Pedagogies and Educational Theories

Jalil et al. (2015) reviewed the MOBIlearn Task Model and demonstrated that this framework plays a significant role in facilitating mobile instructional designers' understanding of pedagogical goals and requirements. Their study also emphasized the following key factors that instructional designers need to pay attention to in supporting mobile activities: subject, object, control, context, and communication.

In Dillard's (2012) *Annotated Bibliography*, the pedagogy of mobile learning was defined to be the approach, skill, and manner of teaching applied by teachers to facilitate learning outside of the classroom. The author generated six principles from the annotated bibliography for guiding the pedagogical and content design of mobile learning.

- Develop a simple and intuitive interface design
- Integrate interactive multimedia
- Build short, modular lessons and activities
- Design activities which are engaging and entertaining
- Design content that is contextual, relevant, and valuable to the learner
- Just-in-time delivery (p. 108)

To derive instructional design principles of mobile learning for higher education, Herrington et al. (2009) conducted design-based research named the New Technologies, New Pedagogies Project. The following 11 principles were extracted from the research:

1. **Real World Relevance:** Design mobile learning that can resolve real world problems
2. **Mobile Contexts:** Design the mobile contexts for learners on the move
3. **Explore:** Allow some time for learners to explore the features of mobile learning
4. **Blended:** Combine mobile and other forms of technologies
5. **Whenever:** Mobile learning can happen any time
6. **Wherever:** Mobile learning can happen anywhere, not exclusively in the classroom
7. **Whomsoever:** Anyone could learn through mobile learning, no matter individually or by group
8. **Affordances:** Explore other functions of mobile learning
9. **Personalize:** Compatibility of learner's mobile device
10. **Mediation:** Mobile learning can facilitate knowledge acquisition
11. **Produce:** Learners can apply the knowledge they learned from mobile learning to generate new knowledge and share via social media.

Mayer (2006) proposed six principles for multimedia learning based on Cognitive Load Theory, which are contiguity, modality, redundancy, coherence,

personalization, segmenting, and pretraining principles. Mayer (2003) also pointed out that the same multimedia principles could be applied to different media. One of the attractions of mobile learning is, it is easy to incorporate multimedia in design, and multimedia is an indispensable element of mobile learning. By this, the multimedia design principles could be used to design mobile learning.

4.2 Platform and System Design

Mobile learning is easily connected with online learning or e-learning. Many researchers tried to explore the common points and differences between the two, and Elias (2011) is one of those researchers. In his study, he compared and illustrated the relevance of online and mobile learning. Then, he extended the eight Universal Instructional Design (UID) principles which were developed previously for online learning to mobile learning. The eight UID principles are: "Equitable use, Flexible use, Simple and intuitive, Perceptible information, Tolerance for error, Low physical and technical effort, Community of learners and support, and Instructional climate" (p. 147). The UID could guide instructors in designing the operating system and instructional materials of mobile learning.

Hockly (2013) stated that mobile learning is not only suitable for informal learning outside the classroom but also suitable for formal learning inside the classroom. Her work provided a strong representation of using mobile technology for English language teachers (ELT). Further, she applied the Substitution Augmentation Modification Redefinition (SAMR) Model, which was developed by Puentedura (as cited in Hockly 2013), to ELT activities design. The SAMR Model identified technologies' role in mobile learning system designed from the easily achieved Substitution to the complicated Redefinition. Instructors can use technology to backup and improve their traditional teaching (refer to Substitution and Augmentation). For advanced utilization of technology, instructors could innovatively redesign and create their teaching approach (refer to Modification and Redefinition).

4.3 Technology Acceptance

Wang and Shen (2012) synthesized research of mobile learning and explored principles of message design for mobile learning from cognitive theories, content, devices, and methodologies. There are four principles generated from devices and concept direction for message design, "(1) design for the least common denominator, (2) design for eLearning, adapt for mLearning, (3) design short and 'condensed' materials for smart phones, and (4) be creative when designing for mobile devices with 3G and 4G technologies" (p. 567). Additionally, they provided guidance and detailed information about message design, such as including audio, captioning, characters, icons, and colors.

4.4 Evaluation

Evaluation is another key factor in designing mobile learning. Levene and Seabury (2015) utilized an adapted conceptual framework to evaluate mobile learning. It combines the Framework for the Rational Analysis of Mobile Education (FRAME) and Transactional Distance Theory (TDT). This emphasized how student achievement, usability, and student attitude are three aspects to evaluate the mobile learning success. Accordingly, the principles generated from the research to guide the design and evaluation of mobile learning are: (1) design should take students' perception and attitudes into account, (2) the content should be usable and accessible, and (3) design should be aligned with the pedagogical goal.

Another researcher Motiwalla (2007) applied a prototype Mobile Learning System (MLS) to 64 students in a university for two semesters. The goal was to evaluate the effectiveness of mobile learning. The MLS model included content and material delivery and included interactivity between instructor and learner functions. After the intervention, the author deployed a survey and conducted interviews about student usage, evaluating the system's effectiveness through students' perceptions about it. The result of the evaluation showed that most students were satisfied with MLS and believed MLS added value to their learning experiences. Similar with Levene and Seabury's study, Motiwalla's research also acknowledged the importance of learner's perceptions, the interactions between learners and instructors, and the usability of the mobile learning system.

4.5 Motivation and Interaction

Many researchers emphasized the significance of motivation and interaction design of mobile learning. A case study of an entrepreneurship course at a university in Singapore conducted by Menkhoff and Bengtsson (2012) proved that a mobile learning approach including engagement tools such as photo-sharing websites, wikis, and podcasts brought excitement to online learning and supported students in a meaningful, collaborative learning environment.

5 Recommendations of Design Principles

After reviewing the studies and research done by previous scholars, the design principles have taken root in these authors' thinking. It is time to share pedagogically driven guidelines for instructors to design and develop mobile learning systems. The principles will still follow the five categories which were generated from the review of the extant articles.

5.1 Pedagogy and Education Theories

5.1.1 Principle 1: Align Learning Activities with Pedagogical Goals

As defined by Ally and Prieto-Blázquez (2014), pedagogy is "the art or science of being a teacher" (p. 288). The pedagogy of mobile learning is to apply mobile technology in any teachers' approach to facilitate learning both inside and outside of classroom (Dillard 2012). Filho and Barbosa (2013) propose the following learning aspects and criteria that adapt to pedagogical goals: just-in-time knowledge, separate views, content management, educational activities, and adaptation to the context.

Park (2008) conducted research with 182 students at Buldang Middle School in Korea using personal digital assistants (PDA) in music classes. Teachers and students in this study utilized learning activities through mobile devices (PDA) such as text, images, graphics, multimedia, and sound to facilitate the teaching and learning process. Laine et al. (2010) designed four mobile games in 3 years which aimed to develop game-based mobile learning. They invited 343 players to test the mobile games. During the development of the four games, the researchers determined that the context should be adapted to the pedagogical requirements. The above studies demonstrated that identifying the pedagogical goals of mobile learning is a design precondition. All the learning activities should be designed in the aim of realizing pedagogical goals, otherwise, the direction of the mobile learning deviates. Therefore, it is significant to design mobile content, curricular and learning activities to conform to pedagogical goals.

5.1.2 Principle 2: Design Learning Activities Based on Educational Theories

According to Ertmer and Newby (2013), learning theories provide sources and a foundation of instructional strategies. The three main learning theories are behaviorism, cognitivism, and constructivism. Behaviorism is how people learn from observable stimulus and response (Driscoll 2012). Teachers repeatedly stimulate students with positive or negative reinforcement until students form behavioral patterns. Cognitivism tries to explore the schema (organization) of the human brain and to figure out how memory is produced and processed in the human brain (Driscoll 2012). Under constructivist theory, teachers' function as facilitators helping students to explore the outside world based on their previous knowledge and experiences (Christensen 2008). Learning occurs during this process. Many well-known educational theories such as Cognitive Load Theory and Community of Inquiry stem from the three learning theories.

Taylor et al. (2006) developed a task model for mobile learning under the guidance of a socio-cognitive engineering approach on a project of MOBIlearn funded by Europe. The socio-cognitive approach is derived from learning theory. They then examined two field studies and synthesized the relevant theories in

analysis. Parsons and MacCallum (2017) assessed six learning theories using a rubric to evaluate mobile learning activities. The six learning theories are:

1. Behaviorism
2. Constructivism
3. Experiential learning
4. Situated cognition
5. Communities of practice
6. Connectivism

They first applied the rubric to an existing 2-h development workshop formed by a large group of teachers. Then, based on the rubric and perspective learning theory, Parsons and MacCallum redesigned the learning tasks. Finally, they evaluated the improved learning tasks concluding that a learning theory rubric is a helpful guide to the cyclical design of mobile learning activities. The two examples demonstrated that the guidance of educational theories could help mobile learning designers to select the proper instructional strategies for targeted learners.

5.1.3 Principle 3: Conduct Learner, Instructor, and Content Analysis

Learners and instructors have different styles and characteristics. Instructional designers should conduct research and analysis to identify the needs, skill levels, and expectations of their counterparts. The methods for analysis could include surveys, interviews, and observations. Hearing from multiple learners' voices helps designers build a more robust and supportive learning system (Baek and Schwen 2006; Baek et al. 2008). Similarly, different learning contents require different teaching approaches. Never begin a design without analysis. During the analysis phase, learners' needs, prerequisites, and entry skills should be collected. Also, learners, instructors, and content characteristics should be determined. Finally, course goals, objectives, and learning steps should be identified (Dick et al. 2015).

Chetwynd (2017) designed a project named Virtual Learning Environment (VLE) to facilitate students in exploring additional examples outside the classroom. Before the design and development of the project, a structure analysis was conducted to evaluate learning and teaching styles. The structure analysis included two phases. The first phase occurred before the design and development, targeted to determine the topic areas and the desired key features of the VLE project. After the prototype was developed, the second phase of analysis was conducted to test and analyze the prototype. Inviting the same group of undergraduate students at Plymouth University, both phases of analysis were conducted through focus group interviews. The first analysis outlined a set of learner desired features, and most of them were implemented by Chetwynd into the VLE prototype. This study revealed that conducting learner, instructor, and content analysis could help instructional designers determine the characteristics of the target learners and instructors and further decide the desired contents and functions.

5.2 Platform and System Design

5.2.1 Principle 4: Design Platform and System to Be Flexible with Content Format

Lacking face to face communications, mobile learning systems need to increase interactions between learners and instructional materials to enhance learners' initiative. Different content formats can mobilize students' positive perspectives of learning. Multimedia is a good way to interpret and illustrate content in mobile learning systems. The mobile learning platform and system should be able to recognize and support different formats of files. For example, Parsons et al. (2006) highlight the significance of utilizing rich and proper media objects to support content in their m-learning framework project which was implemented in the United Kingdom. Jalil et al. (2015) also carried out a systematic review of the MOBIlearn task model framework and discovered that multimedia resources are one of the contributing factors for MOBIlearn to support educational purposes. Multimedia resources which include video, audio, images, text messages, web pages, presentations, and other interactive materials can improve users' experiences of mobile learning.

5.2.2 Principle 5: Embed Online Support in the Platform or System

The degree of satisfaction of mobile learning experiences depends on the users' technological skills. According to Baek and Schwen's (2006) research, technological problems are the major obstacle for users with limited skills. Online support could provide instant help to learners and, thus, meet participants' needs. To discover the constraints of a Bring Your Own Device (BYOD) project, Song and Kong (2017) conducted a research study through observing and field notes of 17 teachers' classes in the Hong Kong Institute of Education. They found that higher educational teachers needed technological assistance with operating the mobile devices as well as in designing the mobile learning activities. Peters' (2007) research interviewed 29 business and education providers in Australia and discovered that providing customer service in mobile technologies could significantly increase the efficiencies in mobile learning.

5.3 Technology Acceptance

5.3.1 Principle 6: Access to Different Mobile Devices and Systems

Unlike online learning, different mobile devices are designed based on different mobile operating systems. The two major mobile systems in the current market are Apple iOS and Google Android. Mobile learning applications need to be designed for at least two versions that use both operating systems. For instance, Dlab et al. (2017) led a design-based research study of math learning in an elementary school in Croatia. A mobile learning system named SCOLLAm (Seamless and Collaborative Mobile Learning) was developed. During the design phase, they stressed the importance of a mobile learning system that can adapt to the two major platforms and the

different types of mobile devices. The mobile application would lose large numbers of users if not applicable in the two main mobile application markets.

5.3.2 Principle 7: Provide High Error Tolerance

The mobile learning application needs to be simple enough for participants to use easily. However, it must also be complex enough to serve participants' needs (Baek and Schwen 2006). Using an online study of Japanese university students, Lau et al. (2017) investigated users' needs in mobile learning. The results showed that content display issues are barriers for most subjects in mobile learning. Users would quickly discard a mobile application when they frequently encountered system crashes. Instructional designers should test for edge and critical scenarios to increase the error tolerance of the system before going live.

5.3.3 Principle 8: Apply to Both High and Low Quality of Internet

Due to the characteristics of mobile devices, mobile learning relies on a network. Occasionally, every user faces some time that the signal of a network is weak. For instance, people will be frustrated to find that they have free time to learn during their commuter time, but due to network on the transportation being weak, their mobile learning system cannot be used. Usually, the size of multimedia files is large and, thus, requires high Internet speed to download. Compressing the size of files in the system without reducing the quality of the files can help increase download speeds and perform better in low Internet speed areas. Designing mobile learning that functions properly, even in low quality of Internet areas, or provides background load processes will add power to the mobile learning application.

Song and Kong's (2017) research on 17 teachers reported that the unstable Internet connection and slow file transmitting speed were annoying to students and discouraged them from incorporating the BYOD in their classes, whereas some of the teachers who resolved the technological issues were able to explore more through this project. To sum, mobile learning must flex to different mobile devices, adapt to both iOS and Android mobile application platforms, and overcome technical constraints by increasing error tolerance and providing alternative solutions in slow Wi-Fi speed environments. When those issues are resolved, more and more teachers and students will accept and adapt to mobile learning.

5.4 Evaluation

5.4.1 Principle 9: Conduct Formative and Summative Evaluations During the Whole Process of Designing Mobile Learning

Formative evaluations collect information during the design and development phases of the product, while summative evaluations collect information at the final stage of the design and development of the product. Both evaluation types assist in making decisions about whether the instruction meets original expectations

(Dick et al. 2015). Why bother with two forms of evaluation, though? According to Dick et al. (2015), the previous scholars found that the performance of the designed learning products was not as good as expected and had limited effectiveness. In reviewing the scenarios, they expanded the concept of evaluation to include formative evaluation and summative evaluation. By conducting the two kinds of evaluations, reflections from learners are encouraged. This learner feedback then allows for timely revisions after each evaluation phase.

Much design-based research follows a cyclical process with continual reflection and refinement. Dlab et al. (2017) used the process of modifying their SCOLLAm by first identifying learners' and teachers' requirements, then exploring their perceptions after using the product. Afterwards, they revised accordingly and then gathered information again to make continued improvements. Similarly, Chetwynd's (2017) VLE project carried out at Plymouth University begins with analyzing learners' and instructors' desired topics. From there, it designs the prototype, investigates the results by evaluating users' critiques about the strengths and weaknesses of the prototype. The researchers then evaluate users' reflections and revises the product. Thus, evaluation not only encourages progress but also improves a mobile learning product.

5.5 Motivation and Interaction

5.5.1 Principle 10: Motivate Learners by Interactive Activities

Learners may feel isolated in their learning experiences because of the asynchronous features of mobile learning. Strengthening the social component of mobile learning can increase its ability to establish individual and group relationships in virtual learning environments (Garrison 2009). It may also contribute to increased awareness of learners' self-regulation.

In a study conducted by Shen et al. (2009), researchers pointed out that a lack of interactivity in many Chinese online classes which provided only recorded lectures led to two consequences: distancing students and encouraging passive learning. Shen et al. (2009) developed a mobile learning system which provided customized live broadcasts of real-time classrooms together with real-time text message polls involving 562 students and instructors in the e-learning lab of Shanghai University. Through a survey, the researchers concluded that students may feel disconnected from their classes if interactivity is insufficient. They went on to conclude that providing more opportunities for students to work in study groups would increase interaction. Instructional designers could expand the communications tools in mobile learning design. Increasing learner-content interaction to the learning material would make learning become dynamic and attract learners' attention. Increasing learner-learner and learner-instructor communication would help to create mobile learning communities and build an effective and efficient mobile learning environment. Mobile social media is one of the convenient and ready-to-use ways to increase learner-learner interaction and learner-instructor interaction.

6 Case Study of a Mobile Learning Application: Visualize TOEFL Speaking (VTS)

Visualize TOEFL Speaking (VTS) is a mobile application, designed and developed by the Master of Arts in Instructional Technology Program Team at California State University, San Bernardino (CSUSB). The purpose of the VTS is to help learners practice English speaking skills for the TOEFL test. It is an interactive mobile learning platform, which incorporates various learning activities, such as watching lectures, viewing tutorial videos, uploading users' voices for instructor feedback, and participating in online discussions.

Figure 1 is a screenshot of the main functions of VTS. The pedagogical goal of this mobile application is that international students will improve their TOEFL speaking skills through a self-paced, mobile learning course. It aims to create an interactive learning experience through the following three aspects. First, this is a professionally designed learning course developed by a team of instructional designers including faculty and students, subject matter experts (SME's) who have taught TOEFL courses for over 15 years, and a programmer. Second, the mobile app's course content is based on the most current TOEFL speaking test. Finally, the mobile app's third aspect is its in-time feedback. Instructors provide feedback within 24 h to each student's oral practice through the mobile app. All of these elements are in accordance with Principle 1: Align Learning Activities with Pedagogical Goals.

Figure 2 is the screenshot of a sample course. The learning activities are designed under the guidance of constructivism, which allow learners to watch the tutorial videos, upload their voice, receive feedback from instructors, orally practice more, and interact with other learners in the discussion forum. Teachers play the role

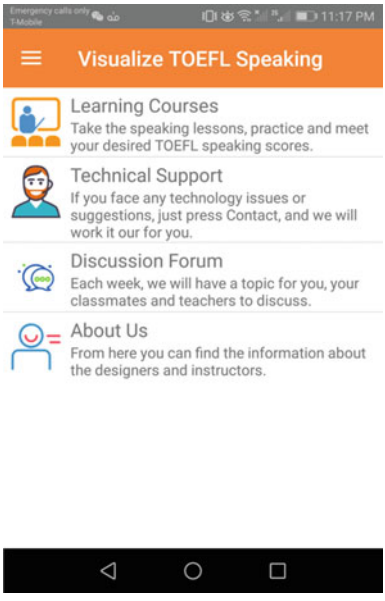

Fig. 1 Main functions of VTS

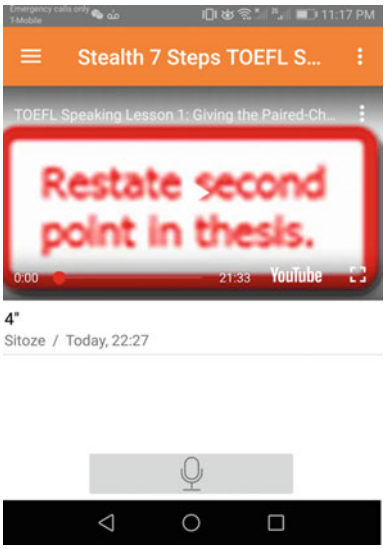

Fig. 2 Sample course

of facilitators in the mobile learning course. This guided feedback accords with Principle 2: Design Learning Activities Based on Educational Theories.

Following the ADDIE (Analysis-Design-Development-Implementation-Evaluation) instructional design process, the development team conducted surveys and interviews with English language program students and instructors at CSUSB. With the learners and the instructor, the team performed content analysis by reviewing existing resources related to TOEFL. The content areas that most students and instructors identified as significant problem areas were selected to be main features of the application – speaking about a given topic and free topic. This is consistent with Principle 3: Conduct Learner, Instructor, and Content Analysis.

Figures 3, 4, and 5 are screenshots of sample courses, which embed multimedia files. Except for the tutorial video demonstrated in Figs. 2, 3, and 4 are screenshots of the voice recording, reviewing, and saving processes. Figure 5 shows the discussion board, which allows learners to provide peer reviews and to communicate with instructors. The application provides multimedia to enhance learners' initiative and learning. The rich format of content demonstrates Principle 4: Design Platform and System to Be Flexible with Content Format.

There is a technical support function designed into the mobile app. Figure 6 shows a screenshot of technical support that also includes a user satisfaction survey. Both of these reflect Principle 5: Embed Online Support in the Platform or System.

The designers already developed the Android version and are now working on the IOS version. After the IOS version is ready to use, the mobile application will fulfill Principle 6: Access to Different Mobile Devices and Systems.

When designing the mobile app, the instructional designers keep it simple by focusing on only one area, speaking. This ensures participants' ease of use. At the same time, the mobile app provides complex functions allowing learners to upload

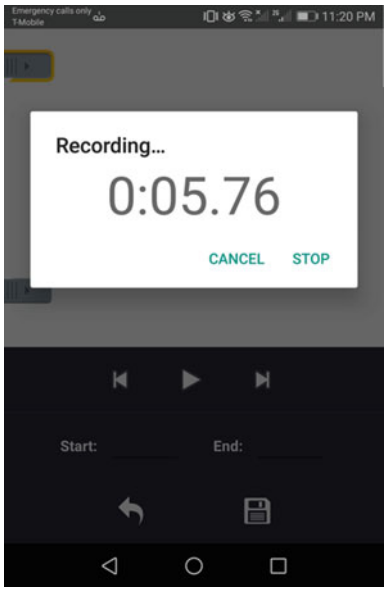

Fig. 3 Record learner's voice

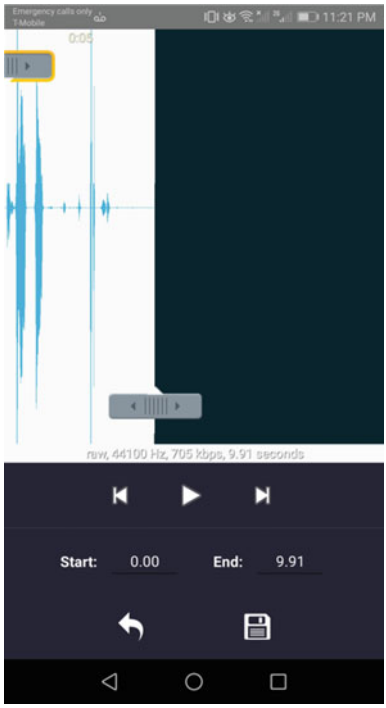

Fig. 4 Review and save learner's voice

Fig. 5 Discussion board

Fig. 6 Technical support

their voices and receive feedback from their instructors. This is an effective way to practice TOEFL speaking according to the instructor and learner analysis. While testing the mobile app, instructional designers received user feedback to improve the interface design and increase high error tolerance, thus fulfilling the requirement of Principle 7: Provide High Error Tolerance.

The tutorial videos in the mobile app are externally connected through YouTube. The size of multimedia files is smaller than integrating the large size of video directly in the mobile app. This design compresses the size of system files without reducing multimedia quality. This also increases download speed, which aligns with Principle 8: Apply to Both High and Low Quality of Internet.

Upon the above mentioned technical support function, after users proposed suggestions, the VTS will revise and update according to customers' reflections, and a new version will be released for user download. This demonstrates Principle 9: Conduct Formative and Summative Evaluations During the Whole Process of Designing Mobile Learning.

The functions of uploading learners' voices, discussion boards, and instructors' feedback are consistent with Principle 10: Motivate Learners by Interactive Activities. As presented in Figs. 2, 3, 4, and 5, learning activities deploy various multimedia which require students to be motivated and engaged in diverse interactions.

7 Future Directions

In this chapter, we recommended ten design principles through an in-depth literature review. The ten design principles are classified by a framework with the following five categories:

(1) Pedagogies and Educational Theories
- Principle 1: Align Learning Activities with Pedagogical Goals
- Principle 2: Design Learning Activities Based on Educational Theories
- Principle 3: Conduct Learner, Instructor, and Content Analysis

(2) Platform and System Design
- Principle 4: Design Platform and System to Be Flexible with Content Format
- Principle 5: Embed Online Support in the Platform or System

(3) Technology Acceptance
- Principle 6: Access to Different Mobile Devices and Systems
- Principle 7: Provide High Error Tolerance
- Principle 8: Apply to Both High and Low Quality of Internet

(4) Evaluation
- Principle 9: Conduct Formative and Summative Evaluations During the Whole Process of Designing Mobile Learning

(5) Motivation and Interaction
- Principle 10: Motivate Learners by Interactive Activities

The ten principles are chosen due to their importance in designing and developing mobile learning. As with any effective technology integration, designing mobile learning takes an alignment of the content knowledge with pedagogical and technical knowledge (Mishra and Koehler 2006; Koehler and Mishra 2008).

The ten design principles are currently adopted within higher education to varying degrees. These principles serve as a comprehensive framework for the design and development of mobile learning, which allows educators and instructional designers to harness opportunities offered by mobile learning. Even though these principles are intended as guidelines when designing and developing mobile learning, these can also be utilized as an analytical framework when evaluating mobile learning.

Future study is needed to utilize the above-mentioned principles to design a mobile learning system appropriate for formal learning in higher education. After a system is developed, action research must be conducted to evaluate the mobile learning system's effectiveness. Considering the rapid development of mobile technology, systematic examinations of research about mobile learning will provide insights and help continue to revise and refine these principles.

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