Designing and Developing Mobile Based Instruction: A designer's perspective

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Abstract
Mobile devices are increasingly being used in classrooms and corporations as a means to deliver instructional content. Currently, there is limited research on how to best design and develop mobile based instruction. As a result, the purpose of this research study was to examine students' perceptions of designing and developing mobile-based instruction by a) interviewing instructional design graduate students in a computer based instruction course who were given the opportunity to construct mobile-based instruction and b) surveying instructional design graduate students to uncover their perceptions of mobile instruction design, usability, and delivery. Results of the survey and qualitative data analysis indicated that usability was a key issue on the mobile device. Users enjoyed quick access, good organization, user control, single column layouts, and large links/buttons. These findings contribute to the literature base on the design and development of mobile based instruction.

Key words
Mobile, Mobile Based Instruction, Designing and Developing Mobile Based Instruction, Mobile Guidelines, Mobile Learning, M-Learning

RESEARCH

Introduction

Mobile learning is an emerging area of distance education. ELearning was transformed by the internet and now it is being redefined by the power of mobile wireless technologies (McGreal, 2009). There are now 5.3 billion mobile subscriptions globally, and in developing countries a majority of people can access the Internet from their mobile devices (International Telecommunication Union, 2010). This has provided educators with an opportunity to deliver meaningful learning via mobile devices. Mobile learning is not just about redesigning eLearning into a smaller package so that it can be played on a mobile device. It includes considering the new possibilities that being mobile and connected can offer, such as the lack of defined learning space. Currently, there is much research on the use of mobile devices for learning (Wishart, 2009; Naismith and Smith, 2009). Given the nature of mobile learning, this research varies widely as there are a variety of uses for mobile devices. However, there is a dearth of research on how to best design instruction for the mobile device. As a result, educators and researchers are in the process of determining best practices for the design and development of mobile content for instructional purposes (Ally, 2009). This paper focuses on a case study research project that was conducted on designing instruction in a mobile environment in order to help frame recommendations for mobile design.

Mobile Learning

Stevens and Kitchenham (2011) define mobile learning (mLearning) as "the use of a wireless handheld device; a cell phone, personal digital assistant (PDA), mini-computer, or iPod to engage in some form of meaningful learning" (p. 3). According to Woodill (2011), mobile learning is about providing engaging and challenging learning activities that result in a change in the behavior of the learner and includes giving the learners the freedom to learn anytime and anywhere. It includes both informal and formal learning settings that can be used in a variety of ways. For instance, Attewell and Savill-Smith (2005) recommend that mobile learning be used to encourage both independent and collaborative learning experiences, to help learners identify areas where they need assistance and support, to help remove some of the formality from the learning experience and engages reluctant learners. Mellow (2005) adds that mlearning is a powerful method for engaging nontraditional learners or for those groups of students who cannot participate in classroom learning and need the flexibility to participate at their convenience.

Mobile learning has been described as personalized, learner centered, situated, collaborative, ubiquitous, and lifelong (Sharples, Taylor and Vavoula, 2005). Researchers have attempted to classify mobile learning. According to Traxler (2009) there are six different types of mobile learning that have emerged from the research including technology driven mlearning, miniature but portable eLearning, connected classroom learning, informal/personalized/situated mobile learning, mobile training/performance support, and remote/rural/development mobile learning. This paper fits into the miniature but portable eLearning category, where mobile, wireless, and handheld technologies are used to redesign conventional eLearning to mobile devices.

Current Use of Mobile Devices in Education and Training

Mobile devices are currently being used in a variety of ways in education, as well as many other industries. For instance, they have been used extensively in museums, hospitals, universities, corporate and government settings, K-12, etc. In general, these devices shine in environments where it is inconvenient to take a computer. For instance, when outside the classroom and on the move mobile devices carry advantages that personal computers lack

Who?	How mobile devices are used?	Author of the Study
Nurses	Reference nursing software at the patient's bedside to reference information such as drug interactions and lab values was cited as the most useful feature of the mobile devices in nursing practice.	Kenny et al. (2009)
Teachers	Teachers used mobile devices for personal support with timetabling, records of meetings, observations, students' attendance and grades, images, and just-in-time information from the Internet.	Wishart (2009)
Doctors	95 percent of physicians that owned smartphones reported downloading applications to access medical information.	Dolan (2010)
Journalists	Journalists use the various functions of smartphones to write, record audio and video, take photos, and keep abreast of breaking news.	Vaataja, Mannisto, Vainio, and Jokela (2009)
Museum Visitors	Deliver learner-centered experiences in a museum without compromising the aesthetic appeal of the museum and most visitors found the experience to be fun and engaging.	Naismith & Smith (2009)

Table 1. Use of Mobile Devices for Educational Purposes

(Pastore and Land, 2011). Some of these portable advantages include GPS, SMS messaging, and anywhere internet connectivity. In the classroom, these devices can be used as clickers and even have some capability to replace computers. Having said that, mobile devices are limited by their size and lack of a large keyboard. As a result, it should be noted that mobile devices will probably never be able to replace a full size monitor/keyboard device unless it were set up in a docking station. In this section we provide some examples on how mobile devices are being used in these settings for learning purposes.

In this first example, mobile devices are used at Duke University in the Duke Digital Initiative (DDI). The goal of DDI at Duke University is to promote innovative and effective teaching, to use technology in support of curriculum enhancement, to develop technology infrastructure, and to share knowledge about effective instructional technology strategies. Thus academics are encouraged to use mobile technologies in their classroom. For instance, an English professor used iPads in his writing course where he investigated several ways that iPads might impact student learning, including direct comparisons of iPad use vs. non-iPad use. He found that students using iPads were better prepared for class discussions and made better use of the Mind Mapping brainstorming software due to the stylus and touch screen capabilities. Another professor had Russian language students practice writing in cursive with iPads in hopes of helping teach handwriting skills and provide an opportunity to practice writing in a low-stakes environment (DDI, 2010).

Another example includes Abilene Christian University which was recognized as an Apple Distinguished Program for its work to understand the impact of mobility in education, to discover and create new ways to make learning more engaging and to develop new teaching resources that allow teachers and learners to leverage mobility through iPads, iPhones and iPods. ACU found three emerging themes in the use of mobile devices in classrooms: increased independence for learners, enhanced communication and engagement, and a more individually tailored and contextual learning experience (ACU, 2012).

Al-Fahad (2009) surveyed 180 students on their attitude and perception of use of mobile technology in education. It was found that the majority of students at his institution in Saudi Arabia supported the notion that the wireless networks increase the flexibility of access to resources in learning. These students also perceived mobile technologies as an effective tool in improving communication and learning, even in developing countries where mobile technologies are not yet popular due to the high cost involved. Ismail, Gunasegaran, Koh and Idrus (2010) surveyed 105 undergraduate students on their satisfaction related to mobile learning. They found that distance education students in Malaysia were satisfied with mobile learning as it helped in the delivery of the study material, important notes, and daily reminders. The students highly agreed that mobile learning helped them pace their studies in distance learning courses. With mobile devices being used in a variety of ways in education and training, it is becoming important for instructional designers to learn how these devices are

being used, and then design instructional materials that are delivered via the mobile devices.

In addition to the cases discussed above, the following table highlights uses of mobile devices for educational purposes across several industries:

Mobile Usability and Design

ISO defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". (ISO, 1998). Nielsen (1993) defines usability as "a quality attribute that assesses how easy user interfaces are to use". Nielsen (2003) pointed out that usability is defined by five quality components. 1) Ease of Learning, 2) Efficiency of Use 3) Memorability 4) Error Frequency and Severity and 5) Subjective Satisfaction. The key to usability is to figure out how to apply these traits to interfaces that meet both client and user needs. There are various design recommendations one can allude to, such as the golden principle, rule of thirds, and grid layouts. However, each of these once applied needs to be tested to ensure they meet usability standards. Thus, how can Nielsen's usability components be applied to the interfaces?

On the mobile device, Nielsen (2011) reported that website use on mobile devices received very low scores on usability, especially when users accessed "full" sites that weren't designed for the mobile platform. The usability issues in the study were categorized into four main hurdles: small screens, awkward input, download delays, and mis-designed sites. Thus, when designers followed guidelines on design for computer based interfaces, they did not apply to the mobile device. Later, when websites specifically designed for mobile devices were tested, their success rate averaged 64%. An 11% increase on user performance led Nielson to believe in the importance of creating mobile-optimized sites. These sites were more pleasant to use and also received higher subjective satisfaction ratings. As a result, this indicates that normal web design and multimedia guidelines which apply to larger screen, such as desktops, do not apply to the smaller mobile device. Nielsen (2011) also found that the usability of a mobile app is better than a mobile website. A mobile app is an application which can run directly on a smartphone without the need to be connected to the web. They can access hardware features of the phone such as the GPS. The mobile website, on the other hand, requires internet access, uses the browser, and cannot access hardware within the phone. They measured a success rate of 76% when people used mobile apps, which is much higher than the 64% recorded for mobile-specific websites. As a result, it would appear that developing a native app for the mobile devices leads to greater usability than developing for the mobile web. Furthermore, Nielsen reports that users have become more aware of horizontal swiping, which is often used to "flip" through deck-of-cards or carousel features on mobile apps, whereas websites usually do not have this feature or navigate in this manner.

Lobo et al. (2011) lists usability guidelines for mobile websites: keep it simple, simplify user input, scroll vertically only, have multiple versions of the website, and avoid repeating the navigation. Additionally, Nielsen (2011) recommends that content should be targeted towards the audience and be presented in chunks so as not to overburden the user's working memory. To have a successful mobile site or app, he recommends that the most important guideline is to design for the small screen. Some users struggle to hit tiny areas that are much smaller than their finger, which is called the fat-finger syndrome. The second guideline is that when you have a small screen it is better to limit the number of features and only include those that matter the most for the mobile user. Wang (2004) claims that best-practice design principles for context-aware mobile learning will take considerable time to develop, but are critical.

In addition, a number of authors highlight similar conclusions. For instance, Horton (2011) in his book *ELearning by Design* recommends guidelines for designing on the mobile devices. He describes that the display screen is small for a smartphone and moderate for a tablet, so one has to keep some guidelines in mind when designing, which include: design for easy reading and fit the content into the small display, minimize navigation controls, emblems and logos, put unessential navigation controls and content at the bottom of scrolling content, and minimize use of wide photographs, tables and diagrams. Similar recommendations were made by Jonssen & Jedde (2009) who lists a set of qualities for the presentation of content which includes: design intuitive interface, provide easy access to instructions, provide user control of the flow of information, support for direct manipulation of objects on the screen, illustrations and visualizations, link with symbolic representations, support for different learning modalities or 'intelligences', and physical activities and access to supportive tools such as calculator or graphing aids.

Ally (2009) provided some design recommendations for developing mobile learning instructional material. Some of the suggestions include using the multimedia capabilities of the latest mobile phones to make the learning

experience stimulating and to design the instructional material in manageable chunks. Griffin (2011) suggests to design mobile content by dividing content into two minute segments, delivering content in conversational style, delivering how to instructions that can help one be better, smarter and faster, identifying and delivering content in areas that one needs to do better, and developing mobile learning that make the experience elegant and emotional. And finally, Quinn (2011) recommends focusing on the 4Cs of mobility when designing for the mobile device which include: content, capture, compute and communicate. Quinn recommends minimizing file sizes for prose, graphics, audio, and video, as large file size can hog the bandwidth and memory resources. For text, Quinn recommends that you do not need full sentences. Phrases that communicate the information are sufficient. For graphics, he recommends using simple diagrams. For audio, he recommends using voice talent, as this can make a difference when the file is compressed to low quality. Further, generic mobile design guidelines have been provided by a number of researchers (Baudisch and Holz, 2010; de Sá and Carriço, 2008).

The research mentioned in this section provides designers' guidelines to consider when building apps or websites that will be displayed on the mobile device. However, little of this research considers instructional development, much of it focuses on development of information websites. While this is important to instructional designers, this does not help define usability guidelines that one should follow when developing mobile based instruction, as the interface and interactions can have a different purpose than an information website or mobile application. As a result, more research needs to examine the mLearning interface as it applies to mobile based instruction.

Research Purpose

The purpose of this research study was to examine students' perceptions and experiences during the design and development of mobile-based instruction. Current research on mobile learning focuses on the use of mobile devices and the design of mobile interfaces, however very little research has focused on the design as it applies to mobile-based instruction that is intended for learning. As a result, the following study was conducted by a) interviewing instructional design graduate students in a computer based instruction course who were given the opportunity to construct mobile-based instruction and b) surveying instructional design graduate students to uncover their perceptions of mobile instruction design, usability, and delivery. Experiences of the participants were captured throughout the design and development process and are presented in this study.

Methods

This study utilized a qualitative and survey research design, which examined participants' experiences developing and using mobile-based instruction. Data collection consisted of interviews, observations, and product analysis, which are described by Stake (1995) as a means to triangulate data. Additionally, a survey was distributed. Together, these helped to ensure that the data was cross-checked via multiple sources in order to establish quality and credibility (Lincoln & Guba, 1986). Descriptions of the participants, data collection techniques, and analyses are described below.

Instructional Setting

This study took place in an instructional technology graduate program at a southeastern university in the United States. This instructional technology program includes three courses that emphasize the design and development of mobile-based instruction. These include: *Mobile Learning, Gaming in the Classroom*, and *Computer Based Instruction*. The *Mobile Learning* course covers design and use of mobile devices for learning. *Gaming in the classroom* covers design and development through visual development software (*MIT App Inventor*). *Computer Based Instruction* covers design and development (this process is described further in this paper). Students in each of these courses took part in the survey for this study (28 students), however, only students in the *Computer Based Instruction* (8 of the 28) course participated in the project described below and participated in the interviews, observations, and product analysis.

Survey

A survey was developed to help examine how users perceived mobile websites designed for instructional settings. The survey consisted of 35 questions and was geared towards learners in instructional design classes who were developing mobile-based instructional websites or instructional designers who have used mobile-based instructional websites. The first ten questions of the survey were made up of demographic information. The final twenty-five questions were based on a seven point Likert-scale and ranged from (7) Very Important to (1) Not Important (See Table 2 and Table 3). Items from the survey were identified from the literature review and broken into two sections: Mobile web design and Usability.

The mobile web design section of the survey, displayed in Table 2, focused on features of mobile-based instructional websites. It was designed to examine users' preferred characteristics of mobile websites. Participants were asked how important each of the following features was when

accessing a mobile website. The mobile usability section of the survey, displayed in Table 3, was designed to examine participants' perceptions of usability features associated with mobile-based instructional websites. Users were asked if they preferred each of the features when accessing a mobile website.

A reliability analysis of the Likert-scale items revealed a Cronbach's Alpha of .857. An alpha above .70 is acceptable (DeVellis, 2003).

Participants and Data Collection

The survey participants included 28 graduate students (13 Male, 15 Female) from three Instructional Technology courses during the Fall 2011 and Spring 2011 semesters that were utilizing mobile design and development in their courses. Participants' ages ranged from 23-40. Survey data was collected via survey monkey. This data was used to help determine design recommendations for mobile instruction.

Interviews, Observations, and Product Analysis

Description of the project

In the spring of 2011, the *Computer Based Instruction* course focused on designing and developing instruction for the mobile web. As a prerequisite for the course, students had to take at least one instructional design course and one multimedia course. All students coming into the class had a fundamental understanding of instructional design models and multimedia design principles. The first half of the semester focused on computer based instruction, where students developed instruction using Adobe Flash. The second part of the semester focused on mobile web development using Adobe Dreamweaver and HTML.

For the mobile project, students were asked to develop a 10-minute instructional tutorial on a topic of their choice, which could be viewed on any mobile-based web browser using Apple, Android, Windows, or Blackberry based smartphones. The students entering the course had very little web development experience, thus they were first presented with a training session on Adobe Dreamweaver where they learned how to create basic web pages with links, images, and tables. Once students understood how to develop basic web pages, discussion on mobile-based web design and usability took place. Recommendations and design practices, as identified in the literature review from this paper, were discussed.

Students were then given three class periods to develop their mobile websites. It should be noted that while students were only given three class periods to develop their sites this was enough time to test multiple designs to see what worked and what did not. However, this is a limitation in this study. During these class periods, the instructor answered questions and observed students' development of the projects. In order to test their websites, students used iPod Touches. These were selected because they function the same as the iPhone without phone connectivity (do not require data services). These were received as part of a grant to explore mobile learning. In order to view the websites on the iPod Touch, students published the website to the internet using their university webspace. When students completed their project, they were published for instructor review. Once websites were completed, they were tested on both Android and Apple IOS operating systems' default web browsers to examine how they appeared. Students then presented their mobile websites to the class. This presentation included a discussion on how they designed their instruction. At the conclusion of the semester, the students in this course were interviewed in order to understand their experiences designing and developing instruction for the mobile web.

Participants

Purposeful sampling techniques were utilized in this study to identify interview participants. They are described by Patton (1990) as a means of selecting "information rich cases...from which one can learn a great deal about issues" using "relatively small samples, even single cases (n=1)" (p. 169). Participants consisted of eight Instructional Technology Masters level students (2 males/6 females). Only students from the *Computer Based Instruction* course participated in the interviews.

Data Collection

Data collection took place before, during, and after the project described in the previous section. Three sources of data were used which consisted of interviews, observations, and final product analysis. These three were chosen as a means to triangulate the data (Stake, 1995).

Interviews took place at the end of the semester when students had completed their courses. Each participant was interviewed in a 20-40 minute interview. The interviews were semi-structured and designed to provide a deep and meaningful understanding of the phenomenon being investigated (Van Manen, 1990). Once interviews were completed, they were coded and transcribed using the Constant Comparative Method (Glaser & Strauss, 1967).

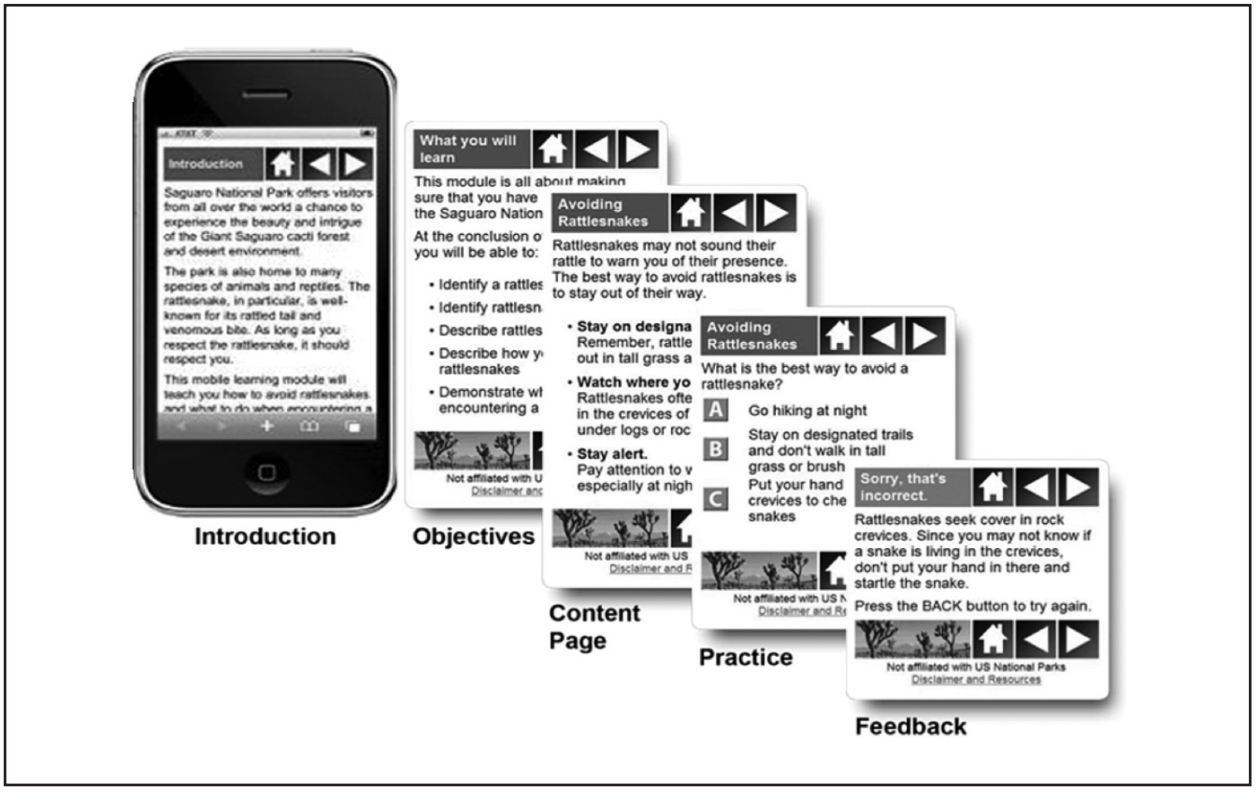

Figure 1: Sample student project

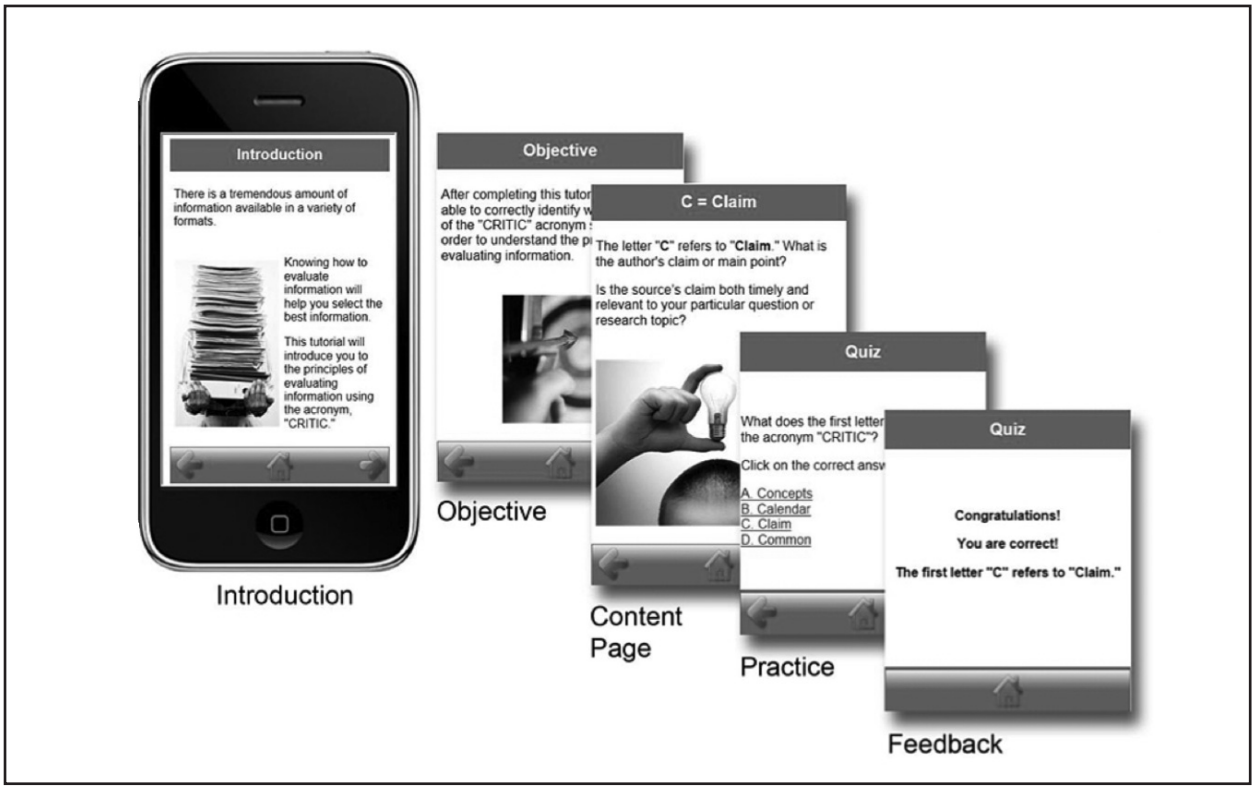

Figure 2: Sample student project

Question	M	SD
Quick access to the information	6.71	.600
Good site organization	6.54	.744
The site provides accurate information	6.54	.693
Site is user friendly	6.39	.737
The site allows you to control the pace at which you interact with the information	6.39	.916
The sequence of obtaining information is clear	6.21	1.101
The site provides current and timely information	6.21	1.031
The site provides the precise information you need	6.21	.917
The site offers content that is relevant to the audience	6.07	.900
The site uses media appropriately to communicate the content	5.79	1.258
The site offers clear and understandable goals	5.71	1.652

N=28. Likert- scale and ranged from (7) Very Important to (1) Not Important
Table 2: Design Recommendations

Observations took place throughout the entire process in order to add meaning and aid in understanding the interview data collected (Creswell, 2007). In this case the researcher was the instructor. This included observing students during three class periods in the *computer based instruction* course where they designed, developed, and tested their instructional tutorials, as well as answering questions through email and office hours.

Final products in the *Computer Based Instruction* course were analyzed by the researcher in order to help make meaning out of the interviews and observations. The final products were examined to compare design recommendations from participants to their instructional tutorials. The products were tested in both Android and iOS operating systems in order to ensure they had the same look and feel regardless of the mobile device used. Figure 1 and 2 provide two sample final products created by the students.

Findings
Findings from this study include both survey and qualitative data. The survey data will be presented first to give the reader design and development considerations encountered by the participants. The interview section will then be presented in order to further explore users' experience designing and developing mobile-based instruction.

Survey
A descriptive analysis was run on the survey results as displayed in Table 2 via SPSS.

Overall, the survey results indicate that many common web design guidelines are important when developing and accessing sites for the mobile instruction including: quick access, good organization and clarity, being user friendly, informational, and user control. These results are very similar to the guidelines suggested by Horton (2011), Griffin (2011) and Ally (2009). Students rated the quick access to information as the highest rated design guideline (M=6.71), which was followed by good site organization (M=6.54) and providing accurate information (M=6.54). The lowest rated item in the design section of the survey was providing clear and understandable goals (M=5.71), and the second lowest being using media appropriately to communicate content (M=5.71). Most of the items were rated above 6 points, and two items were rated in the 5 points range. This emphasizes the importance of all of these design principles.

A descriptive analysis was run on the survey results as displayed in Table 3 via SPSS.

The key findings here indicated that most participants preferred a screen that did not require zooming, was the correct size upon entry, and was a single column layout. For instance, 80% preferred the single column layout (M=5.35) and 63% indicated they did not prefer a multiple column layout (M=4.21). This provides insight into the notion that users do not prefer to zoom and enjoy being able to see the whole page on the screen, as opposed to zooming and scrolling. To further support this conclusion, more than half of the participants preferred links on the top and/or bottom of the screen and 73% indicated that they did not prefer them on the left or right hand side of the screen (M=3.73).

Question	M	SD
Text is legible without zooming	6.04	1.483
Site fits my screen size without adjustment	5.81	1.167
Single column layout	5.35	1.548
Link location on top of screen	4.92	1.719
Text requires zooming for reading	4.57	2.063
Open new browser windows during site use/pop up windows	4.54	2.044
Drop down menus	4.42	2.139
Text entry	4.40	1.756
Link location on bottom of screen	4.23	1.818
Scrolling up and down to view content	4.23	2.103
Multiple column layout	4.21	1.641
Scrolling to the left or right to view content	4.15	2.167
Elements of the site require you to download/install plugins	3.92	2.216
Link location on left or right of screen	3.73	1.930

N=28. Likert- scale and ranged from (7) Very Important to (1) Not Important
Table 3: Usability Recommendations

Qualitative data
The purpose of the interviews was to examine participants' experience designing and developing mobile websites. They were coded for emergent themes using the Constant Comparative Method (Glaser and Strauss, 1967). Seale (1999) describes this method as "a systematic tool for developing and refining theoretical categories and their properties" that is comprised of four stages which include coding into categories for comparison, integrating categories, coming to a point of saturation, and putting it all together (p. 96). The following themes emerged from the interview data under one overarching theme of Design: Space, Layout, and Transition. Each theme is presented below with a discussion from the case as well as quotations from participants in order to give the reader an in depth understanding of the participants' experience. Data from the observations and product analysis is also discussed within these results.

Design: Space
Space refers to size of the screen on the mobile device. Space is used as a general term to encompass various terms participants used to described developing on the mobile device. Many of the participants agreed with Horton's (2011) recommendation that the mobile instruction should be developed with the small screen size in mind. Horton recommends making the text legible, limiting graphics, and making use of the real estate on the screen.

Participants often referred to the screen as a very small landscape that was small in size and needed to be kept simple and clean. This was essential as the mobile device only allows for a small amount of space to work with. Participants suggested making good choices about design so that the screen did not feel cluttered, for instance:

> "I would tell people to keep, keep it simple, to really keep it simple, because when you are looking at something on a computer screen, you just have a lot more space. There's a lot more space. You can allow it to get a little bit busier. There can be more things going on, but when you get something down to, you know, the size of a phone, of an Android or iPhone or something, then you don't have as much room. You have to really make good choices about what it is you are going to put in there. Because there's just, it can get cluttered really quickly. And because everything is so much smaller, obviously it looks different on the computer than it does on the phones. So, I'd say just make good choice about font, size, and type and then graphics. And, navigation. I would say make the navigation as simple as possible."

Participants also suggested that the mobile device created such a difference in size that it was as if looking through a telescope when compared to a PC. At first participants were defining the width of the mobile instruction to correlate with the iPod screen size. This was done by

specifying a width in the HTML and CSS files they were developing in Dreamweaver. However, when they viewed their instruction on other devices that had a different screen size, the instruction appeared too small or required side scrolling as it was too big. As a result, participants had to create their instruction using percentage widths, that way, regardless of the size, it would utilize the devices screen size as it was intended. It should be noted that doing this can cause pixilation, a term used to describe a distorted screen, and should be tested when users may be accessing the mobile site on tablets and full sized monitors. The following comments help to illustrate this point:

> "And one comment I wanted to make about viewing things on a mobile device something I've kind of feel when I'm on my smartphone is I feel like I'm looking at things through a telescope because you've got this big page but yet you've got this little small viewing area so your trying to move that viewing area around so you can find out where you going. But that on pages not set up for mobile devices. So it's like looking through a telescope."

> "To make it so that it would look best on all screens, because there's a difference in size from three inches long to maybe two and half inches long. It just varied. And, then, uh, especially with, uh, what do you call 'em, Smart pads almost serving the same purpose that, uh, when I tried to pull it up on my iPad, it was, the resolution was poor. So, trying' to the understand the specific, the sizes that you are supposed to make everything for it work most effectively while maintaining a small file size was problematic."

Several participants noted that simplicity was key to good design on the mobile device. They mentioned that in order to make it simple you should not be 'flashy'. They wanted the fluff out and realized that plug-ins were not going to be convenient in the online environment. This is inline with Ally (2009) who recommends taking the fluff out and organizing content into manageable chunks. The following quotations, from participants, help to shed light on this recommendation from the literature:

> "Um, I think it's easy, it needs to be for all levels of technology users. Um, simplicity, uh, not flashy, to the point, if you are gonna use an image or text, just use simple images and not flashy text. Um, think about even dis, you know, disability users that may not be able to see, um, you know, that need bigger print, you know, just make sure the text is ,uh, compliant, I guess ADA compliant and the pictures are simple graphics that are universal. Um, I think about anyone can see it."

> "thinking of the design layout, um, doing it more of a, instead of a macro bigger scale, more of a micro scale, um, trimming down some of the extra flashiness that you can do in a bigger, um, basic web site. Be more simplistic in a smaller mobile layout, um, but still having come across the same information and not to lose that content."

The findings in the space section highlight how important the real estate can be on a mobile device. Content needs to be organized with limited text and graphics that fit into the screen design. Otherwise content can easily be cluttered. This could lead to increased cognitive load for the user which would depress learning activity. This could also lead to bad design which could cause user error. It is recommended that future research explore how these design issues affect the cognitive abilities of the user.

Design: Layout

Layout refers to design considerations that participants encountered as they were developing their projects. Participants noted many things that they needed to focus on during design and development, which included the page layout, buttons, and scrolling issues. They found that when creating a page, they needed to make the page one column. More than one column would make the page illegible unless the user was going to zoom in to see the page. Using multiple columns did not utilize space well even though websites for computers can and do commonly have multiple columns whereas one column with a header, content, and footer fit the mobile device. Additionally, throughout the design and development process participants explored locations to place links and navigational buttons. Participants thought that in order to best use space, placing links at the top, bottom, or both gave users easiest access to them. Here participants discuss the layout:

> "Keep it simple and clean in your design. Avoid lots of words and graphics, simpler is best when it comes to the web. The 1 column design is very helpful in keeping content on the mobile screen."

> "And, the use of a header, a content and a footer, an actual framework, um, was really important so that you could have consistency through each page."

Button positioning was also highlighted as an important consideration. The following quote focuses on the location of the buttons and follows Horton's (2011) recommendation that buttons should be at both the top and bottom of the screen when vertical scrolling is involved in the landscape. Students realized that putting

buttons at both the top and bottom of the screen (if there was scrolling) would help to alleviate the amount of scrolling that users would have to do.

> "One of the things that I didn't do initially, but that I changed, you know, in my final product was putting the back and forth buttons on the top and the bottom. So that when you scroll down you can hit 'em, you don't have to scroll back up to the top. So that was something I hadn't thought about until I saw another student's project."

Other participants indicated that the buttons and links needed to be big. They should be large enough to easily be pushed by a user's finger, otherwise participants might have to press multiple times if they missed or would end up pressing the incorrect button.

> "Have big buttons, big clear things, very limited graphics so it downloads fast. If you do use graphics, make sure you compress 'em down to mobile size, instead of having, you know, your regular jpegs for your, um, your computer."

> "Make the buttons and links BIG. I would avoid using the underlined text link and instead use buttons big enough for the tip of the finger."

Most of the participants agreed that the less scrolling involved on the mobile device the better. Each time a user scrolls, they need to touch the screen and this can lead to user error due to accidental button presses. One user notes that button presses add an extra step for the user that should be avoided if possible:

> "I don't think it should all, I don't think it should be much of any scrolling just because that's an added step with your finger."

Most of the participants felt that scrolling caused distraction and should be limited on the mobile platforms. This follows the idea of simplicity when developing content:

> "You don't want to spend a lot of time scrolling or going all over the place" and "try to fit as much content on the actual screen without the user having to scroll as much."

Inherently, design considerations will be key to user-friendly interfaces. Layout features, such as a single column with a header, content, and footer will help designers keep content on the screen without asking users to zoom. Buttons and links should be large enough to be pressed with the user's finger so that they do not need to zoom or press incorrect links when trying to access another screen. Additionally, scrolling should be kept to a minimum. Each time the user scrolls they have a chance to press an incorrect button. Horizontal scrolling should always be avoided.

Design: Transition

The final theme uncovered during the analysis was transition. Participants tended to agree that there was a transition period (they needed to adapt) from the computer to the mobile device. Not only did they need to make adjustments in their design of software, but also they needed to focus on the hardware as they were going from a mouse and keyboard to a touchscreen with a mobile keyboard. Here two participants discuss how developing for the mobile device was easier because they could not create complicated designs, interactions, and layouts. They alluded to the fact that they were designing for a simple environment with just one column, which made actual design and development easier because there was less focus on placement then there can be with computer based instruction:

> "Again, the mobile web was just so much easier. I think, um, just having the one column made it a lot easier. There was less to, for me anyway, there was less to think about as far as aesthetics. And so, it was just, it was just so much simpler. And, I liked that it was just one column. It was one column; it was some back and forth buttons. And, it was just….it was more fun. I don't know I really liked...I mean I liked it…it was fun."

> "It was like developing a mini web site. Very interesting perspective – going from big screen to small screen. Had to keep everything simple and linear."

Another participant discusses the differences between having a mouse vs. using your finger. While mobile devices do have a keyboard, the mouse and cursor becomes your finger. This can make development tricky as people have different size of fingers so button/link placement and size become critical. Recommendations throughout the whole process were that buttons and links needed to be large enough to be pressed by the finger in order to reduce user error:

> "What I noticed. I think when you go from using a laptop to using like a smartphone, and I have a smartphone now, I think the differences from going from that where you use a keyboard and a mouse to the touch is that you realize how big your fingers are and just a link is not going to be very effective anymore. You need big

buttons. You need to direct the learner on where they need to touch to go to the next screen. There is really no pop ups, no imbedded flash type things, its like going from one screen to the next. It seems very linear."

These results indicate that there is a transition period when going from development on the computer to development on the mobile device. On the design and software side, users should have clear recommendations and usability guidelines so that they can better make the transition. On the hardware side, there is a significant difference; thus design needs to accommodate that by ensuring that hardware usability is designed with the mobile keyboard and finger as a mouse in mind.

Discussion and Conclusion

Mobile is the new frontier in eLearning. Currently, 5.3 billion people have mobile phones in the world and that number is multiplying at a fast rate (International Telecommunication Union, 2010). Increasingly educators are using these devices in the classroom and corporations are implementing them into their eLearning. However, there is limited research on how to best design and create usable applications for mLearning. As a result, the purpose of this research study was to examine students' perceptions of mobile-based instruction design and development by a) interviewing instructional design graduate students in a computer based instruction course who were given the opportunity to construct mobile-based instruction and b) surveying instructional design graduate students to uncover their perceptions of mobile instruction design, usability, and delivery.

Results of the survey and qualitative data analysis indicated that usability was a key issue on the mobile device. Users enjoyed quick access, good organization, and a lot of user control. Among these findings are recommendations for those developing mobile-based instruction which should be taken into consideration. These include screen size and zooming, button and link size (hardware usability), layout, plugins, and data use. Users indicated that since the screen size was small, content needed to be simple. Otherwise the screen would get cluttered very easily. This could easily increase cognitive load and/or increase user error. It is recommended that future studies examine this phenomenon. Button and links on the mobile device need to be larger. Users had to use their fingers instead of a mouse, which can easily cause error if links are too close together. Thus links need to be far enough apart as well as large enough for a learner's finger. The layout of the page also made an impression on users in this study. Common web layouts are two to three columns. However on the mobile device, a layout of that nature creates an environment where content is not viewable unless the user zooms. As a result, a single column layout with a header, body, and footer is recommended with links at either the top or bottom of the screen (or both top and bottom). The use of plugins was not recommended by any users. They felt it was an extra step and could be difficult to download depending on the users speed of their data connection. Thus the speed of the connection was an important issue that one needs to account for when designing mobile based instruction. It cannot be assumed that all users will have wifi during training, thus files sizes for graphics, videos, and sounds need to be managed as some users may have 3G speeds. However, it should be noted that 4G speeds are becoming more widely available. Additionally not all cell phone plans have unlimited data usage, so large files can be costly for those with limited data plans. Thus the smaller the files, the better.

The findings in this paper add to the literature base on the design and development of mobile based instruction. As the need for mobile-based instruction grows, we will need to look at the findings in this paper and consider them when instruction is being developed. Instructional designers will need to examine these findings to see how they fit their current needs and decide whether to implement mobile based instruction or not. Future research on this topic should expand the current study to examine ways to design content for mobile devices (i.e. do the multimedia principles hold?), best practices for using mobile devices in instruction, and instructional strategies that best support mobile learning (i.e., motivation). Additionally, quantitative studies that determine how to improve achievement with the mobile device would be beneficial.

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Designing and Developing Mobile Based Instruction: A designer's perspective

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