Considerations for Instructional Message Design in Mobile Learning:

A Design and Development Study

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Abstract

In the past decades, teaching and learning has undergone rapid transformation partly because of advances in technology and access to such technology (Sung, Chang, & Liu, 2016). Mobile technologies (i.e. tablets, smartphones, and access to Internet) have become widespread, and is visible, even in the developing world (Aguayo, Cochrane, & Narayan , 2017). Mobile technologies allow for online learners to access learning resources on the go (McQuiggan, McQuiggan, Sabourin, & Kosturko, 2015). Instructional message design principles advance empirical tools aimed at producing lessons that allow for effective learning (Bishop, 2014).

The purpose of this study was to develop a set of considerations for designing messages for mobile learning primarily through literature review and expert reviewers' feedback. The research methodology employed in the study is based on design and development research methodology (Richey & Klein, 2007). The study utilized Clark and Mayer's (2016) multimedia principles, Center for Universal Design's (1997) universal design for instruction (UDI) and mobile interface design best practices

Five expert reviewers with varied expertise in human computer interaction, special education, mobile learning, and instructional design were sought to review the considerations and provide feedback on its effectiveness for instructional message design. Overall the expert reviewers agreed that the considerations were effective and will be helpful to instructional designers, instructors of instructional design and content developers. They provided several helpful recommendations which were used to revise the considerations for designing content for mobile phones.

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General Audience Abstract

In the past decades, teaching and learning has undergone rapid transformation partly because of advances in technology and access to such technology (Sung, Chang, & Liu, 2016). Mobile technologies (i.e. tablets, smartphones, and access to Internet) have become widespread, and is visible, even in the developing world (Aguayo, Cochrane, & Narayan, 2017). The Mobile technologies allow for online learners to access learning resources on the go (McQuiggan, McQuiggan, Sabourin, & Kosturko, 2015). Instructional message design principles advance empirical tools aimed at producing lessons that allow for effective learning (Bishop, 2014).

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Dedication

To My Husband Kwame Ansong-Gyimah and our Kids Kobby, Kwaku, Kofi and Nana Ajoa Gyimah

"For the Mighty One has done great things for me; And holy is His name" Luke 1:49.

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Chapter One

Introduction and Need for the Study

Background to the Study. Mobile devices, for the purpose of education, have become a popular way for students to learn and access information (NMC Horizon Report, 2017). As of fall 2016, there were over 6.3 million students taking at least one distance education course, which is inclusive of 31.6% of all higher education enrollments (Seaman, Allen, & Seaman, 2018). In fact, the article states that, "The number of distance education students grew by 5.6% from Fall 2015 to Fall 2016 to reach 6,359,121" (Seaman, Allen, & Seaman, 2018, p. 3). Researchers see the potential of mobile learning because of its portability, cost-effectiveness, and communication features (NMC Horizon Report, 2017). Mobile learning (mLearning) is defined as learning that takes place via wireless devices such as mobile phones, personal digital assistants (PDAs), and laptop computers (O'Malley et al., 2005). McQuiggan, McQuiggan, Sabourin, Kosturko and (2015) defines mobile learning as, "the experience and the opportunity afforded by the evolution of the educational technologies, it is anywhere anytime learning enabled by instant on-demand access to a personalized world filled with tools and resources" (p. 8). As online and distance learning continues to gain popularity, the need for instructional designers will also continue to increase (Beirne & Romanoski, 2018). The limitations of mobile devices for learning purposes are gradually being discounted. For example, screen size was once a limiting factor. However, in recent years, screen sizes for mobile devices have increased tremendously.

Using mobile devices in teaching and learning dates back to 1992 when John Sculley, CEO of Apple Computer came up with the term personal digital assistant (PDA) (Roschelle, 2003). Before 1995, no one ever spoke of "mobile learning," but the concept still existed. Books

may represent the oldest support for mobile learning with people using them on trains, airplanes, and boats. People then started realizing that PDAs also had potential for learning (Roschelle, 2003). Today mobile devices are used everywhere and for many different reasons, playing a future role in online learning outcomes (Gezgin, Adnan, & Acar Guvendir, 2018). Thus, many sectors of society have resolved to use mobile technology to deliver services to customers (Ally & Prieto-Blázquez, 2014).

Nearly two-thirds (63%) of cell phone owners use their phones to go online (Duggan & Smith, 2013). The Pew Research Center is an independent statistics center that enlightens the public about the subjects, thoughts and developments affecting the world. Internet & American Life Project referred to cell phone owners as "cell internet users" (Duggan & Smith, 2013). They further defined these users as anyone who uses their cell phone to access information from the internet or through email. Furthermore, 91% of all Americans now own a cell phone, and that 57% of American adults are cell internet users (Anderson, 2015). As of February 2018, 95% of Americans own a cell phone of some kind (Mobile fact sheet, 2018).). The number of cell phone owners who use their phones to go online has doubled since 2009 (Anderson, 2015). Also, as of 2017, mobile internet views accounted for 49.9% of the populations worldwide (Statistica, 2018)

According to the Groupe Special Mobile Association (GSMA) Intelligence (2018), there are currently over five billion mobile subscribers in the world today, dramatically illustrating the huge potential for mobile learning. Additionally, Anderson's (2015) Pew Research Center report has found that 30% of smartphone users have used their phones to take a class or access educational content. Pearson Student Mobile Device Survey (2015) also suggests that eight in ten (86%) college students regularly use a smartphone. This number is up from 83% in 2014. With the widespread use of mobile devices in education for teaching and learning purposes, there is a

need to ensure that information presented on the mobile device screen is designed to help learners comprehend the information displayed. Mobile learning designers must decide whether they are planning for a wider audience or for the purpose of supporting a learner's unique needs (Miller & Doering, 2014). The latter is the focus of this study. The desire is for every designer to create meaningful material that learners can easily digest.

MLearning is of potentially high relevance to developing countries (Alkhalifah, de Vries, & Rampersad, 2017). Developed and developing countries have both adopted mobile learning in a huge way (Keegan, 2002). Further, Alkhalifah, DeVries, and Reampersad (2017) have also stated that:

> Significant research on the acceptance and potential adoption of mobile technologies have demonstrated that the uptake of Information communications technology (ICT) and mobile learning could provide effective tools in developing countries, along with traditional methods. (p. 92)

Using these wireless technologies in education may help to prevent the digital divide in developing countries, as these devices are cheaper than desktop computers (Ally & Samaka, 2013). As an example, some places in Africa have areas that are underdeveloped. According to Barker, Krull, and Mallinson (2005), many African countries are technologically behind, which contributes to the educational divide. As a result, a lot more people depend on mobile phones to browse the internet and access educational content (Brown, 2008). As a result of lack of infrastructure in most African countries, mobile wireless use is a big part of the peoples' lives. Barker et al. (2005) stated that many people in Africa have mobile phones instead of fixed phones indicating considerable potential for mLearning in these areas. However, there has been tremendous growth of infrastructure in Africa. Anderson' (2015) research on cell phones in

Africa indicated that currently, cell phones are as common in South Africa and Nigeria as they are in the United States, and that the use of mobile phones has allowed Africans to skip the land phone era entering into a digital age. The ICT Fact and Figures (2016) indicated that about one in two people (47%) in developed countries are using the internet, but only one in seven people are using the internet in developing countries. This indicates that there is a digital divide but that the popularization of mobile phone usage may help to close the gap. According to GSMA (2018) mobile economy report on the mobile economy in sub-Saharan Africa, mobile adoption in the region has grown tremendously in recent years, with subscribers reaching 44% in 2017 (an increase of 25%) at the beginning of this decade.

The adoption of these technologies can help enhance the use of mobile phones for learning purposes. Though these technologies are being used by wide range of distance learning students, effective design of the content is crucial for learning to take place. Research by Clark (1983) supports the notion that media does not affect the learning outcome of a particular lesson, but rather, the methods that are used in the delivery of the instruction contribute to the attainment of the stated goal. This includes the effective design of instructional materials. Clark (1993) further noted that when new technology is implemented without changes in pedagogy the only educational outcome that can be reliably predicted and improved upon is its efficiency. Thus, the role of technology in education has primarily been to deliver consistent and replicable instruction to a large number of people. From Clark's (1983) statement, it can be deduced that mobile devices do not contribute to the achievement of the goal, but that careful planning and implementation of the material will help learners achieve their aim. It is crucial to design the educational messages on the mobile devices effectively to ensure that there is an appropriate degree of cognitive load. Cognitive load refers to the volume of content that the active part of

human memory can process at a given time. There are three types of cognitive load, extraneous, intrinsic, and germane cognitive load (Sweller, 2011). Extraneous cognitive load, concerns with the "unnecessarily increased demand on mental processing (i.e., noise) that result from the way in which the content is presented" (Larson & Lockee, 2013, p. 206). Intrinsic cognitive load deals with "the amount of mental processing required by a learning task, based on its inherent complexity" (Larson & Lockee, 2013, p. 207). Germane cognitive load " is processing that relate directly to the content and helps the leaner perceive and process the information more easily" (Larson & Lockee, 2013, p. 206). One approach to reducing cognitive load in instruction is through effective instructional message design.

Getting the appropriate amount of the desired cognitive load is affected by the message. An instructional message is, "a pattern of signs (words, pictures, gestures) produced for the purpose of modifying the psychomotor, cognitive or affective behavior of one or more persons" (Fleming & Levie 1993, p. x). A message also, "provides a setting for new information that is conveyed by a message" (Gibbons, 2014, p. 215). "The term message however does not denote a particular means or vehicle of instruction" (Fleming & Levie, 1993). Further, Fleming and Levie (1993) go on to explain design as a thoughtful process of analyzing and synthesizing instruction. This starts with an instructional problem and plans to solve that problem. Instructional message design can also be explained as, "the systematic and purposeful process of making decisions about communication" (Dye, 1997, p. 1). This involves decisions about both the content ("what") and the delivery ("how") of a message (Dye, 1997, p. x). Effective learning components design should conform to the principles of cognitive load theory (Chandler & Sweller, 1991; Sweller, 2011).

With the popularity of mobile devices for learning purposes, instructional designers must adhere to sound instructional design principles to warrant rigorous and meaningful instructional material. Over the last decade, there has been significant interest and debate in the areas of cognition and education, however, knowledge of the cognitive processes involved in understanding instructional material has been somewhat limited (Chandler & Sweller, 1991; Sweller, 2011). Reducing the levels of extraneous cognitive load through redesigning instructional materials, for instance, may enhance learning outcomes especially for mobile devices that have smaller screen sizes (Sweller, 2011). Also, a design that adheres to design principles will place images, spoken language, and printed words in proper combinations to maximize instructional effectiveness (Wang & Shen, 2012). In a study conducted by Shadiev, Hwang, Huang, and Liu (2015), it was suggested that inadequate instructional design could lead to extraneous load. As such, designers should be sure to plan instructional content appropriately.

Research Problem

The absence of evidence-based guidance related to the design of mobile learning is problematic as online enrollment is increasing. It is evident that many online students access course content using their mobile devices (NMC Horizon Report, 2017). Thus, a design that adheres to design principles or guidance will place images, spoken language, and printed words in proper combinations to maximize instructional effectiveness (Wang & Shen, 2012). Guidance towards incorporating principles of instructional message design, multimedia learning, and universal design for learning is necessary.

Purpose of the Study

The purpose of this research is to develop a set of considerations for designing instructional messages for mobile learning primarily through literature review and the feedback

of expert reviewers. Current considerations for designing lessons for mobile devices will be made available for content developers, designers, and instructional design professionals as well as principles to follow when creating experiences for mobile devices. A careful and comprehensive study of existing literature confirms earlier studies (Gao, Vincent-Layton, 2015; Haag & Berking, 2015; Novak, & Tang, 2009; Saleh & Bhat, 2015; Shen, Wang, Wang & Shen, 2012; Wishart, 2009) showing that very little empirical exploration has been conducted in the area of instructional message design in mLearning. As a result, there is a need for more systematic empirical work focusing on instructional message design for mLearning in order to design engaging instructional materials for mobile devices. While an increasing number of researchers are working on proposing specific mobile visualization techniques, no work in the literature has provided an empirical broad-based discussion of mobile learning design principles that could be useful to designers and developers of mobile applications for learning (Chittaro, 2006). This research also investigates multimedia and universal design principles for instruction along with multimedia application to mobile learning content development.

Benefits of the Study

The results of the study provide insight into the ways instructional messages are designed in order to impact distance learning through mobile phones to a target audience that is gaining more access to powerful mobile devices. The principles will help content developers to align with what is most compelling for effective instructional content. Instructional designers will benefit from this research, as it provides principles to use for designing lessons for mLearning. The research work, when completed, will add to the limited literature on instructional message design in mobile learning resources. It will also provide evidence-based considerations based on

expert reviewer recommendations, as well as existing research that could be used to produce effective lessons and courses for distance education delivered via personal mobile technologies.

Organization of the Study

This study is organized into six chapters. Chapter One examines the background for the study, which includes definitions for relevant terms. Chapter One also includes the research problem statement, the purpose of the research, and benefits of the study. Chapter Two is a review of the relevant literature for the study. This chapter comprises an overview of mobile learning, mobile interface design, a summary of instructional message design principles, and instructional message design principles applicable to designing instruction for mobile devices. Chapter Three presents the research design and methodology, and provides elaborate information on the choice of instructional message design principles, instrumentation, study procedures, sampling and strategies, data sources, data analysis strategy, and research participants. Chapter Four presents the findings from a broad literature review of mobile learning, instructional message design and mobile interface design best practices conducted during the analysis phase. This section also includes the development and evaluation process for the considerations on designing content for mobile phones. Chapter Five details the expert reviewer feedback and discussion. This includes the review of considerations' report on expert reviewers, overall expert reviewer perspective, and recommendations from expert review. Finally, Chapter Six includes the conclusions and recommendations consisting of an overview of the study, limitations, recommendations for implementation, potential contributions, suggestions for further research, and summary.

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Chapter Two

Literature Review

This study produced considerations to follow when designing content for mobile learning, especially for mobile phones. These considerations suggest ways to convey an idea by carefully integrating words/typeface, images, and sounds into an instructional message. The instructional considerations were developed through a careful search of the literature and subsequent review by experts in the relevant area of specialization. Chapter Two reviews the relevant literature associated with the purpose of the study, which served as a foundation for building the considerations.

This literature review addresses the following research areas: Mobile Learning, Mobile Interface Design, Instructional Message Design, and Instructional Message Design Principles for Mobile Learning.

Introduction. In the past decades, teaching and learning have experienced rapid change due in part to technological advances and access to such technology (Sung, Chang, & Liu, 2016). Mobile technologies (i.e., tablets, smartphones, and access to the internet) have become widespread, and this is visible even in the developing world (Aguayo, Cochrane, & Narayan, 2017). The adoption and leveraging of such resources into education (even within traditional mortar and brick school systems) are commonplace (Pew Research Center, 2017). Thus, there is a growing need to provide readily accessible learning resources (including content, collaboration, and feedback) to today's learner (Digital Accessibility Toolkit, 2016). Mobile technologies allow learners to access such learning resources on the go, and designing lessons that can be accessed using mobile devices requires considerable planning and research. Instructional message design

principles advance empirical tools aimed at producing mobile content, leading to effective learning (Wang & Shen, 2012).

This research focuses on determining the instructional message design principles that could be used to produce educational content delivered through mobile technologies such as tablets and smartphones. The characteristics of mobile technologies, such as size, methods of interaction, connection speeds, and locations of use set them apart from other forms of communication media (Naismith, Lonsdale, Vavoula, & Sharples, 2004). All of these characteristics affect time of use, duration of use, and characteristics of potential learners.

Mobile Learning

Background. Mobile learning has undergone many changes in recent years. According to Sharples, Arnedillo-Sánchez, Milrad, and Vavoula (2009), "over the past decade, mobile learning has grown from a minor research interest to a set of important projects in schools, workplaces, museums, cities and rural areas around the world"(p. 233). As a result of mLearning's portability and low cost, researchers realize its potential to impact learning (NMC Horizon Report, 2017). For the purpose of this study, mobile learning or mLearning will be defined as learning that takes place via such wireless devices as mobile phones, personal digital assistants (PDAs), or laptop computers (O'Malley et al., 2005).

The past decades have observed a transformation in communications and computing technology, with the launching of digital cellular phone networks and the evolution of mobile computers and digital cameras (Boulos, Wheeler, Tavares, & Jones, 2011). Mobile device use is on the rise in the world today. The use of these devices in education is becoming popular in both developed and developing countries (Traxler, 2007). McQuiggan et al. (2015) also stated that, "mobile devices add a level of engagement to any activity and seem to captivate those students

who are often otherwise disengaged" (p. 49). This phenomena, which started from decades ago, has continued to grow rapidly.

The existence of more than five billion active mobile phones worldwide dramatically illustrates the huge potential for the mobile learning (mLearning) market (GSMA Intelligence, 2018). With the ubiquitous use of mobile devices in education for teaching and learning purposes, there is the need to ensure that information displayed on the mobile device screen is designed to help learners comprehend the information displayed on it without an overload of information. A study conducted by Magda and Aslanian (2018) on 1500 online college students showed that 65% of students used technology in some form in their online classes, 12% did not but would have liked to, and only 23% would not want to. These figures demonstrate a great need to look closely at designing content for mobile learning. With so much mobile device use, and specifically for students to access instructional content, mobile learning designers must decide whether to design for a wider audience or to support learners' unique learning needs (Miller & Doering, 2014).

Definition of mobile learning. The use of mobile devices for learning purposes has evolved rapidly from its onset to the present age. Mobile learning has drawn recognition from researchers of diverse disciplines who have recognized the potential of applying mobile technologies to enhance learning (Keskin & Metcalf, 2011). In mLearning's short existence, researchers have attempted to define and describe it in many ways. Prominent in these definitions are a focus on media, mode of learning, flexibility, and relationship to e-learning. Table 1 is a compilation of some definitions of mobile learning, sources, and the focus of these definitions from the researcher's point of view. The criteria for choosing the following definitions were based on focus within the scope of mobile learning.

Table 1:

Compiled Definitions of Mobile Learning

Definition	Source	Focus
1. The provision of education and training on PDAs/palmtops/handhelds, smart and mobile phones.	Keegan (2005)	Mobility
2. Mobile learning is eLearning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone.	Quinn (2000)	Mode of learning
3. Any service or facility that supplies a learner with general electronic information and educational content that aids in the acquisition of knowledge regardless of location and time (p. 100).	Lehner & No¨sekabel (2002)	Location and time
4. Learning that is supported by mobile devices, ubiquitous communications technology, and intelligent user interfaces.	Sharma & Kitchens (2004)	Communication
5. The acquisition of any knowledge and skill through using mobile technology, anywhere, anytime that results in an alteration in behavior. (p. 1)	Geddes (2004)	Location
6. E-learning using mobile devices and wireless transmission.	Milrad (2003)	Relation to e-learning
7. Any educational provision where the sole or dominant technologies are handhelds or palmtop devices.	Traxler (2005)	Technology
8. "The process of coming to know through conversations across multiple contexts amongst people and personal interactive technologies."	Sharples et al. (2007)	Pedagogy, technological devices, context and social interaction
9. "The experience and the opportunity afforded by the evolution of the educational technologies, it is anywhere anytime	McQuiggan et al. (2015)	

Definition	Source	Focus
learning enabled by instant on-demand access to a personalized world filled with tools and resources."		Location, technology and personalization

Note. Adapted Data from a compilation of mobile learning definition.

Based on the research conducted, viewpoints on defining mobile learning generally fall within the following categories: Use of mobile devices such as PDAs, mobile phones, iPods, PlayStations, and portable computers, the connection to e-learning, supplementing formal education, learner-centeredness, and personalization.

Basic Elements and Characteristics of Mobile Learning. With the above definitions in mind, this section describes the basic elements and characteristics of mLearning. Ozdamli and Cavus (2011) suggested that the basic elements of an excellent mLearning environment include the learner, teacher, content, environment and assessment. Each of the elements above has specific roles to play in creating a productive learning experience. Table 2 highlights the roles that each of these elements plays in the mLearning environment.

Table 2:

Elements of Mobile Learning Environment

Element of mLearning	Role Played in mLearning
Learner	Access information when they need Responsible for own learning Learning with their learning speed Discover and use their learning styles Create and share new information or product Study with their peers collaboratively Evaluate themselves and other groups
Teacher	Qualified to use required mobile tools and technologies

Element of mLearning	Role Played in mLearning
	Determine the strengths and weaknesses of the methods used, and study to resolve the weaknesses with different methods Facilitator guide Advisory Learn with their students Increase the motivation of learners Arrange activities to support interactions between Collaborative groups Arrange activities for evaluation of process
Content	Enable a user to quickly zone in to needed information Supports with graphics, video, and other multimedia elements
Environment	Must increase interaction between students and students-teachers, through the use of wikis, social media, and blogs
Assessment	Provides the pieces needed to evaluate the learner's knowledge accurately Help the learner clear all his doubts based on the course

Note. Adapted from Ozdamli, F., & Cavus, N. (2011). Basic elements and characteristics of mobile learning. *Procedia - Social and Behavioral Sciences, 28*, 937-942.

Mobile learning also encompasses several different characteristics that make it unique. Ozdamli and Cavus (2011) suggested seven basic characteristics of mobile learning. These characteristics indicate that mobile learning is "collaborative, provides instantaneous information, ubiquitous, blended, portable, interactive, and private" (Ozdamli & Cavus, 2011, p. 940). Each of the characteristics mentioned is true of mobile learning and makes it unique.

Devices used for Mobile Learning. Research on mobile learning currently explores the use of handheld computers such as iPads, iPods, e-readers, digital tablets, portable media players for podcasting, and mobile/smartphones (Jacob & Issac, 2014). Mobile devices are cheaper, more portable, and easier to use and maintain than desktop or laptop computers (Burns, 2011).

Park and Jung (2014) defined the mobile device as a, "contemporary learning tool and learning environment and focuses on the factors influencing the mobile users' perceptions of mobile learning and the characteristics of informal learning available for the use of mobile device for learning" (p. 768). Reiser and Dempsey, (2018) also defined a mobile device as a, "device that can be used naturally while standing or walking" (p. 244). Mobile devices permit universal access to information and tools for learning as a result of their flexibility. The International Data Corporation's (IDC) (2018) worldwide quarterly mobile device tracker indicated that, after declining 0.3% in 2017, the worldwide smartphone market is expected to contract again in 2018 before returning to growth in 2019 and beyond.

Research shows that there are more mobile phones connected to the internet in the world than actual desktop computers in countries such as the United States of America, the United Kingdom, Germany, France, and Japan (Chaffey, 2018). Today, mobile devices are used everywhere and for many different reasons (Mobile fact sheet, 2018). Many sectors of society have adapted to use mobile technology to deliver services to customers. In the financial sector, customers now have access to banking services using mobile technology – "in the pocket banking" (Brazzel, 2016 ; The Economist, 2007).

Many distance learning students use mobile devices to view course content as opposed to using desktop computers. According to a new Mobile fact sheet (2018) analysis, 66% of Americans own at least two digital devices – smartphone, desktop or laptop computer, or tablet – and 36% own all three. Previous research from Pew Research Center has shown that owners of multiple digital devices use the Internet more frequently, go online from multiple locations, and are more likely than others to use the internet while "on the go."

The popularization of the use of mobile devices means that they are gradually outnumbering desktop computers. According to the ComScore report (2014), "the days of desktop dominance are over. Mobile has swiftly risen to become the leading digital platform, with total activity on smartphones and tablets accounting for an astounding 60% of digital media time spent in the U.S and what drives this boost is the use of mobile apps." (p. 2)

Ownership of mobile devices has also grown immensely. According Anderson's (2015) technology device ownership statistics, 68% of Americans have smartphones and 45% have tablet computers. Ownership of other digital devices has not grown in recent years. ComScore (2014) shows a clear progression in the number of global desktop and mobile users. The report shows that mobile users overtook desktop users between 2013 and 2014, indicating that more people are using the mobile devices actively as opposed to their desktop computers. Martin (2018)'s latest ComScore report indicated that countries like India, Mexico, and Indonesia have up to four times the number of users on smartphones than desktop users.

Another study stated that there is steady growth in the use of smartphones, cell phones, tablets and e-readers while desktop or laptop, game console, and mp3 reader use declined or stayed the same in the USA from 2004 to 2015 (Anderson, 2015). It is easy to see that mobile device usage currently surpasses desktop computer usage Anderson (2015). Pew Research Center report also showed that there had been huge growth in tablet usage from 4% in 2010 to 45% in 2015 (Anderson, 2015). According to another report by the Pew Research Center (2017), some 84% of American households contain at least one smartphone. All of these studies illustrate through evidence the growth of mobile devices, and indicate the huge potential for mobile learning. Statistics shows that more than eight in ten "U.S. adults now get news on a

mobile device (85%), compared with 72% just a year ago and slightly more than half in 2013 (54%)" (Pew Research Center, 2017)

Portable mobile devices have evolved rapidly since the early 1970s, a period that was significant for the development of mobile technologies. Mobile devices have been reduced in size and cost, but have increased in power, speed, memory, and functionality (Crompton, 2013; Ray, 2015). Another important facet of mobile learning is Wi-Fi connections. Without Wi-Fi, mobile learning would probably not exist. Wi-Fi Bluetooth networks, active/passive radio-frequency identification, and global positioning system receivers, ensure an impressive system of networks to use on such devices (Caudill, 2007).

The percentages of the different devices used in mobile learning can be deduced from a study analyzed by Wu et al. (2012) which revealed that, of the 164 studies conducted, mobile phones were most commonly used for mobile learning (36.55%), followed by PDAs (30.96%), laptop computers (9.14%), iPods (4.06%), mp3/mp4 players (2.54%), podcasts (2.03%), and cameras (1.52%). Cheung (2012) also stated that, "mobile devices are commonly used by distance learning students for learning, and that the usage is mainly on doing an assignment, reading e-books, browsing the Internet, checking e-mails, chatting, and social networking" (p. 89). Further, according to a study conducted by Friedman (2016), 59% of online students have completed a course or part of a course on their mobile device, and 67% of prospective online students stated that they wished to use a mobile device while taking classes. Again, based on the online college students' comprehensive report (2017), "eighty percent of online students use a mobile device during their search for an online program and school, and 40% use their devices to access their online coursework." (p. 14). Current device usage specifies that the, "smartphone is the primary platform in all markets, but it is also worth noting that even in mature markets such

as the US, this platform continues to squeeze share away from desktop and tablet" (Martin, 2018, p. 10). As a result of smaller screens on mobile devices, there is the need to design instructional materials in an effective way to prevent cognitive overload. Previous studies have shown that an individual's prior knowledge determines what level of cognitive load they can potentially have. Prior knowledge is what the learners already know previously about a particular lesson content or subject area.

Mayer and Moreno (2003) suggested "nine ways to reduce cognitive load in multimedia learning". These include:

1. Offloading: Move some essential processing from a visual channel to an auditory channel.
2. Segmenting: Allow time between successive bite-size segments.
3. Pre-training: Provide pre-training in names and characteristics of components.
4. Weeding: Eliminate existing but extraneous material to reduce processing of extraneous material.
5. Signaling: Provide cues for how to process the material to reduce.
6. Aligning: Place printed words near corresponding parts of graphics to reduce the need for visual scanning.
7. Eliminating redundancy: Avoid presenting identical streams of printed and spoken words.
8. Synchronizing: Present narration and corresponding animation simultaneously to minimize the need to hold representations in memory.
9. Individualizing: Make sure learners possess skill at holding mental representations. (pp. 46-50)

History of Mobile Learning. Mobile learning has evolved over the past decade. Sharples, Arnedillo-Sánchez, Milrad, and Vavoula (2009) stated that:

> The fundamentals for mobile learning were laid over thirty years ago with the far-sighted Xerox Dynabook project that projected a "self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook" which would allow children to explore, create and share dynamic games and simulations (Kay, 1972, p. 1).

According to Sharples (2005), mobile learning was started in the early 1970s by Xerox, a photocopy company. They started an educational technology group to develop "the Dynabook" as a personal dynamic medium book usable by anyone. It was during the early 2000s that practical mobile learning came to being. At this time, many people had access to tablet computers, and this gave birth to the idea of giving people access to learning whenever they want, and from wherever they are. The primary focus was personalization – the idea that anyone can have access to materials in their preferred way. Peng, Su, Chou, and Tsai (2009) discuss the "developmental stages of educational technologies which progress through programmed instruction, computer-assisted instruction, Internet-connected e-learning, to the context of wireless mLearning" (p. 172). These developmental stages of educational technology originated in the 1920s, and developed all the way to 2004. They stated that the process began with movie film strips, radio broadcasting, television, computer, multimedia hypermedia, internet, culminating in mLearning.

After mobile learning became popular in the 2000s (with the introduction of tablets), it was used mainly to channel eLearning methods and techniques. This quickly exposed the limitations of PDAs and mobile phones in comparison to desktop computers (Traxler, 2010). It

was mostly because earlier mobile devices were limited in functionality, screen size, processor speed and battery life that most of their functionality was not utilized at the time.

As mLearning continued to evolve, the multiple affordances and devices offered further learner-centered instruction (Traxler, 2010). Traxler describes five ways in which mobile learning offers new opportunities. These include:

1. Contingent learning allowing learners to respond and react to the environment.
2. Situated learning in which learning takes place in an environment related to learning.
3. Authentic learning, where the tasks directly relate to learning goals.
4. Context-aware learning, in which learning is informed by history and environment.
5. Personalized learning in which learning is tailored to individual abilities, interests, and preferences. (p. 131)

In 2005, mLearning became a widely-accepted term for mobile learning and leaped further into learner-centered pedagogies (Traxler, 2005).

Mobile Device User Interface Design

A mobile device user interface (UI) enables full access to, and use of, the capabilities of mobile devices. The increased access to and use of mobile devices has led to dialogue about mobile devices and learning. Having an efficient user interface in place is crucial for users to be familiar and comfortable using the devices. The interface of any mobile device is the most important part of a mobile device to the user. Though the programming code is not seen, users see, hear, and touch these devices for various reasons. To maximize the efficient use of a mobile device, the interface must be properly designed.

Introduction. User interface design for small screens is one of the prominent challenges in the development of mobile devices, mostly because of the small size and functionality of such mobile devices (Gong & Tarasewich, 2004). Although there is an abundance of computer interface research available, mobile interface design has not been thoroughly explored and is somewhat unproven in the literature (Gong & Tarasewich, 2004). "Mobile platforms have called for attention from HCI practitioners, and, ever since 2007, touchscreens have completely changed mobile user interface and interaction design" (Punchoojit & Hongwarittorrn, 2017, p. 1). The user interface on a mobile device is an important part of the equipment to ensure its efficient use. It is important to carefully design it using best practices and design principles. Punchoojit and Hongwarittorrn (2017) stated that "although mobile platforms are becoming an indispensable part of daily lives, true standards for mobile UI design patterns do not exist" (p. 1)

According to Gong and Tarasewich (2004), "handheld mobile devices, including personal digital assistants (PDAs), cell phones, and tablet PCs have become increasingly prevalent" (p. 3751). Mobile devices are one of the quickest growing areas of computing. According to Hoober and Berkman (2012), as the device's functionality and capacity grow, the number of mobile devices used worldwide continues to grow. For example, there were close to 1.5 billion cell phones and PDAs in 2003, and over 3 billion in 2007. Currently there are over two billion smartphone users worldwide, and this is expected to grow in 2019 (Statistica, 2018). Mobile devices are small enough to carry, do not need to be plugged in at all times, are wirelessly connected, are interactive, allow for text entry, and are also contextually aware.

One of the most important parts of using a mobile device is the user interface. The user interface is where users interact with the device the most. The user interface specifies the tool to input as users communicate to determine the outcome (Lal, 2013). The interface is also the part

that people can see, hear, touch, talk to, and understand (Galitz, 2007). The "input" aspect of the interface device is how a person communicates needs or desires to the apparatus. Examples of such input elements may include the keyboard, mouse, one's finger (for touch-sensitive screens or pads), and one's voice commands. The output aspect is how the device delivers the results of actions inputted by the user. Designing an interface for mobile devices is relatively complex. As a result of the mobile device's smaller platform, it is more challenging to design the interface (Gong & Tarasewich, 2004).

Mobile device user interface (UI) defined. A review of the literature on user interface design must begin with a precise definition of mobile device interface design. Mobile device user interfaces have evolved over the years, mainly because they exist to ensure effective communication between humans and the world around them. Galitz (2007) stated that the aim of an interface design is merely to make sure that working with a computer or device is easy, productive, and enjoyable. The user interface design is incorporated in human-computer interaction study:

> User interface design is a subset of a field of study called human-computer interaction (HCI). "HCI" is the study, planning, and design of how people and computers work together so that a person's needs are satisfied in the most effective way." (Galitz, 2007)

Galitz (2007) further describes the user interface as the part of a computer (and its software) that people can see, hear, touch, talk to, or otherwise understand or direct.

The aforementioned definitions of user interface encompass key terms such as see, touch, control, and interact. These words describe forms of manipulation and interaction with the device. Kurniawan (2017) mentioned that, "user interfaces consist of the following components: interaction, navigation, metaphors, and mental models" (p. 354).

Another important facet to defining user interface design focuses, not on the device itself, but rather on the behavior of the user. Garrett (2010) describes user interface design as being, "concerned with describing user behavior and defining how the system will accommodate and respond to their behavior" (p. 70). This definition places emphasis on users, and how the interface can be made to adapt to them, rather than users adjusting to the interface.

Best practices for designing effective mobile device user interface. For mobile devices to be used effectively by users, procedures that are accepted or prescribed as being correct or most effective for designing the user interface should be investigated. The user interface includes the screens, windows, controls, menu, metaphors, online help, documentation, and training. What that the user can see and interact with is part of the interface (Chong, So, Shum, Li & Goyal, 2004). Science Daily (2018) affirmed that user interface design is concerned with computers, gadgets, appliances, machines, mobile communication devices, software applications, and the user's experience and interaction. Brewster (2002) comments on the nature of mobile device screens and states that because the mobile screen is small, it is easily cluttered with menus, apps, and buttons making it harder for interface designers. Because of the size differences, simply taking a desktop computer interface and repurposing it for mobile devices does not work. According to Zheng et al. (2012), it is apparent that learners may face problems of attention and a high cognitive load when using mobile devices. Therefore, best practices must be followed when designing interfaces for mobile devices. Using accepted best practices for mobile devices ensures user satisfaction and maximizes use. These considerations could be valuable to practitioners who develop mobile applications, and to researchers working on mobile interface design and usability. Appendix A highlights some of the best practices from the literature on mobile device user interface design.

Five of the best practices enumerated in appendix A are discussed further. The primary reason for selecting these five "best practices" is that they appear to be universal principles and are highlighted in many of the literature reviews as evidenced in Appendix A. These practices provide useful techniques to reduce short-term memory load, allow for personalization that is user-driven, apply design consistency, utilize screen space efficiently, and to utilize interaction mechanisms.

Reduce short-term memory load. The human brain has limited capacity to keep information for the short term. Long-standing research indicates that information remains in the short-term memory for about seven 7 seconds that it can hold up to three chunks of information at a time (Miller, 1956). There is likely to be excessive short-term memory load, especially when hit with multiple abstract or unfamiliar pieces of data in rapid succession. Reducing short-term memory load is paramount. According to Shneiderman and Plaisant (2010), the designer should avoid interface designs in which users must remember information from one screen to the other. This includes designs that do not force the user to re-enter phone numbers, keep the web location consistently visible, and that allow adequate time for on-screen actions.

Gong and Tarasewich (2004) and Wilmer, Sherman and Chein (2017) mentioned that little memorization should be required when performing tasks on a mobile device, especially when there is more distraction working with a mobile device than with a computer. Using an interaction mode such as sound can be valuable to reduce short-term memory load because some learners learn best when they hear the sound instead of just reading it (Gong & Tarasewich, 2004; Golob, Winston & Mo, 2017).

Allow for personalization/user-driven. Mobile devices are more personal and can be used by only one person at a time unlike land phones and desktop computers which can be used

by multiple people (Gong & Tarasewich, 2004). The literature presents limited evidence of the feasibility of designing UIs in agreement with an individual's personal characteristics (Sarsam & Al-Samarraie, 2018). It is therefore critical to design a mobile interface that allows end users to set up their device to suit their personality and interests. Devices can be personalized by implementing passwords for ease of use to ensure privacy and to meet user needs (Hoober & Berkman, 2012).

Mobile devices are typically purchased as one device for one person. Just as no two mobile device users have the same interests and needs, no two interfaces look the same if the designer allows for some variations in its design. Users vary concerning their physical needs (e.g., eyesight), where they use their mobile devices, and what they are interested in seeing on the screen. For instance, when the device screen is more visible, it shows more text while in a dark environment bigger fonts improve readability (Gong & Tarasewich, 2004). Lal (2013) affirmed that users should have complete control to ensure that the mobile device interface design is personalized. Having complete control includes customizability and personalization of the device to depict individuality, meet user needs, and match user interests.

Consistency. Lal (2013) mentioned that using a similar layout, employing familiar interaction, and keeping a similar user interface (UI) throughout ensures consistency. Gong and Tarasewich (2004) also added that making the look and feel similar across platforms, maintaining similar schemes (color) for desktop and mobile, and ensuring the input and output devices are device dependent warrants consistency.

Uniformity should be employed through the whole user interface when designing. For example, designers should not use certain colors or fonts on the home screen and different ones

for subsequent screens. Shneiderman and Plaisant (2010) concluded that identical prompts, screens, colors, layouts, capitalization, fonts, etc. should be used throughout the whole interface.

Utilize screen space efficiently. One major problem with mobile devices is the small screen size on which to display information. There would be no need to increase the size of the devices since an important attribute of mobile devices is portability and the ability to carry them anywhere. The designer must, therefore, utilize the whole screen effectively to maximize its potential. Nilsson (2009) suggested that to maximize space, one must present items in a list, group them, present effective packing of information, and prevent horizontal scrolling in UIs.

Interaction mechanisms. Users of mobile devices interact with their devices all the time. As a result, the quality of interactivity should be considered when designing the devices. Subramanya and Yi (2006) indicated that some of the ways users interact with their devices include looking up content and directories, querying for content of interest, requesting content at certain times, from the content location, and onto specific devices, providing feedback on programs, and following up on advertisements.

Device challenges. Though best practices for user interface design for mobile devices result in efficient use, there are some challenges in developing content for such devices. What follows are some of these identified device challenges.

Small screen. The convenience and portability of mobile devices are significant advantages that draw many people to use them. However, the small screen size on mobile devices poses a substantial limitation in comparison to desktop computers that have bigger screens. Because the screen is small, a lot of information will not fit on one screen on the go. In these cases, the user has to rely on short-term memory to recall information they had previously seen (Brewster, 2002; Gong & Tarasewich, 2004).

Interruptions. One can be easily interrupted when using a mobile device. Because of the small screen, one may be disconnected from an activity. For example, when a call comes in, all activities have to be suspended to take the call. According to Budiu (2015), the average mobile session duration is 72 seconds in comparison to the average desktop session of 150 seconds.

Touchscreen. The touchscreen functionality on some mobile devices can pose a problem. It is easy to touch something else on the screen accidentally (Buxton, Hill & Rowley, 1985).

Connectivity. Smartphone connectivity problems can affect the design of the devices to some extent. Though a strength of mobile devices for mobile learning is that they can be used anywhere and anytime, limited or nonexistent coverage in a particular area makes a device useless.

Conclusion

With the growth of mobile device usage over the years, there is the need for designers to build user-friendly interfaces to ensure that users take advantage of all the capabilities available for their devices. Mobile devices are portable and can be used anywhere, and anytime. According to Uden (2006), mobile technologies have created the opportunity for a lot more people to have access to information when they need it. This offers new possibilities for students' educational activities in that they can be used at different locations and times.

As a result of the flexibility and ease of use, more and more people are engaging in mobile learning using mobile devices. "Popularity is transforming them from small voice-communication devices to advanced communication devices that provide voice, text, and video messaging" (Subramanya & Yi, 2006, p. 85). To ensure that learners who are using these devices get the most out of it, care must be taken in design. Uden (2006) states that "mobile applications must be carefully designed to justify the limitations of their size, lower processing power, and

low bandwidth"(Uden 2006, p .82). Kurniawan (2017) stated that, "screen size influences the usability performance when using a touchscreen interface on a mobile device" (p. 3).

Best practices can provide a guide for designers and practitioners regarding effective interface design. Several of these best practices from the literature may be useful to developers and professionals. Many best practices have been identified through this literature review. These practices can help to ensure that interface design enables ease of use. As concluded by Sarsam and Al-Samarraie (2018), "creating a design based on preferences due to personality differences means creating an interface that matches a user's demands through its adaptation to his/her behavior. Such design in a mobile learning context could include possibility to improve learners' perceptual experience" (p. 92). Kurniawan (2017) also concluded that bigger mobile devices might be more desirable by some users as they can display more material. As such, mobile device interface designers should consider this when assembling user interface components.

Instructional Message Design

Introduction and Definition. The rigorous design of instructional content ensures that it is clearly stated and easy to understand. To design a meaningful instructional content, designers can begin with clarifying what they seek to achieve – who will use it and how they will use it (Redish, 2000). Ulfia, Mawardi, Mohd, and Jasrial (2017) also mentioned that learning message design could produce personalized learning by manipulating the message. The elements, as stated by Wang and Shen (2012), include language, images, signs, and symbols. Wang and Shen (2012) focused on the importance of instructional message design in how the brain works. They indicate that the purpose of instructional message design is to organize all the components for better accessibility, usability, and learning.

The medium for conveying the message is a vital concept for instructional message design. According to Romiszowski (1988), media carries the message from the originator to the receiver. One of the prominent researchers on media comparison studies, Clark (1983), has concluded that media do not influence learning although the methods used in delivering the instruction do. Well-designed information appeals to readers in spite of the medium (Pettersson, 2012). Crucial decisions about the ways to convey the message help to achieve the set goal. Dye (1997) stated that:

> Every decision about the messages we send, whether conscious or unconscious, deliberate or haphazard, contributes either positively or negatively to the quality of communication. While this approach to instructional message design is sufficient in many situations, it is not enough when the message in question is instruction" (p.1).

To clearly define instructional message design, one must understand the different terms associated with it. A message is the material to be transmitted along with the content and meaning it carries. A message is, " a pattern of signs (words, pictures, gestures) produced for the purpose of modifying the psychomotor, cognitive or affective behavior of one or more persons" (Fleming & Levie, 1993, p. 5). The "sign" in Fleming and Levie's (1993) definition implies the forms a particular message can take. These forms cognitively come to stand for something else, whether they are things or ideas. Anglin (1995) also added that the purpose of the sign is to initiate the blend of the five senses which receive the information. A message could be described as, "a discrete unit of data transmitted through various sensory abilities: sight, sound, touch, taste, and smell." (Dye, 1997, p. 1). Correctly received facts develop into information (Dye, 1997). The transaction is called communication. Petterson (2012) also defined messages as, "information content conveyed from a sender to a receiver in a single context on one occasion"

(p. 94). Dye (1997) further stated that, "messages are sent for a variety of purposes: to inform, to entertain, to persuade, to anger, to soothe" (p. 1). Every message that is sent affects the quality of the information positively or negatively. There is the need to ensure that the message sent is received well and understood by the receiver. The sender of the message has the sole responsibility for making sure that it is well-defined enough for the users to comprehend. The sender of the content is the only one who can ensure that the entirety of the message is clear and meaningful (Deterline, 2006).

Other factors that help one to understand the message are information, learning, and instruction. According to Anglin (1995), these terms represent the purpose of the message to be delivered. Information is described as, "bits and pieces of discrete (content), fragmented and particular" (Wilson, 1983, p. 83). Learning results from the cognitive process within the learner. Instruction, by contrast, happens outside of the learner. Instruction includes organizing and sequencing information for the learning. This may include some essential elements, for example, presentation of information, practice, and feedback (Reigeluth, 2013). Comprehension "results from effective coding, organization, integration and translation of information" (Anglin, 1995, p. 224).

Design is associated with carefully thinking about a process, product, or service before actually implementing it. Researchers have defined design in several ways. Design is the thoughtful process of analyzing and synthesizing instruction, starting with an instructional problem and plans to solve that problem (Fleming & Levie, 1993). Smith and Ragan (1999) also stated that, "the term design implies a systematic or intensive planning and ideation process before the development of something or the execution of some plan to solve a specific problem" (p.4). From this definition, design is essentially problem-solving to achieve one's aim. Smith and

Ragan (1999) further specified that, "design is distinguished from other forms of instructional planning by the level of precision, care, and expertise that is employed in the planning, development, and evaluation process" (p. 4). Good instructional message design requires accuracy on the part of an instructional designer in the systematic design of instructional materials. The design process is associated with a particular lesson and how to achieve one's goal. Seels and Richey (1994) also defined design as, "the process of specifying conditions for learning" (p. 30). Design can also help to present material in a state that is easy to use and comprehend.

Instructional message design cuts across many fields of study. "It is an interdisciplinary field of knowledge, It encompasses influence and facts from more than 50 established disciplines and areas of research" (Pettersson, 2002, p. 4). Instructional message design in the broadest sense comprises the analysis, planning, presentation, and understanding of the content, language, and form (Pettersson, 2002; 2007). Instructional message design can be explained as the systematic and purposeful process of making decisions about communication. Lohr (2011) defined instructional message design as, "the manipulation and planning of signs and symbols that can be produced for the purpose of modifying the cognitive, affective or psychomotor behavior of one or more persons" (p. 1). A message comprises decisions about both the content ("what") and the conveying ("how") of a message (Dye, 1997). "Message design involves planning for the manipulation of the physical form of the message" (Seels & Richey, 1994, p. 31). There should be a correlation between the instructional materials made available to learners and learners themselves. Morrison, Ross, Kalman and Kemp (2011) identify instructional message design as the process of, "creating an appropriate interface between the instructional materials and the learner" (p. 180).

Other terms that are associated with instructional message design include information design and instructional message design. Bishop (2014a) stated that, "instructional message design explores how various media and delivery systems might be used more effectively to help optimize instructional communications within context-specific instructional situations and learner needs" (p. 373). According to Bishop (2014a), instructional message design is the next step in the instructional design analytical process, going beyond determining what approaches will bring about changes in student comprehension. The International Institute for Information Design (IIID), stated that, "Information design is the defining, planning, and shaping of the contents of a message and the environments in which it is presented, with the intention to satisfy the information needs of the intended recipients" (as cited in Coates, Ellison, & Ballantyne, 2014, p. 3).

Instructional message design for learning purposes addresses the cognitive structures of a learner and how they may encode the instructional information presented to them. The research in educational media indicates that both the medium and the message are essential in conveying meaning (Bishop, 2014a). When instruction is poorly designed, the media used for transmitting the message doesn't change the content. Content should be designed effectively to convey the intended meaning (Petterson, 2010). The content of a lesson displayed for learners and the methods used are essential to the clarity of communication. Every decision one makes influences the meaning of the message conveyed, and could impact a learner's understanding (Bishop, 2014b).

Any instructional unit of any form, whether on paper or on a computer, is the artifact of the design process. This artifact signifies the communication between the learner and the content (Morrison, Ross, & Kemp, 2006). The task of the instructional designer is to promote effective

communication between the instructional material and the learner to ensure that learning takes place. Rousseau (1998) suggested that there are four steps of interaction between the viewer and the design to deliver meaning successfully. He indicated that good messages are noticed, encoded and decoded, and comprehended and complied with by the viewer. Failure at any of these four steps means that the designed message was not adequately communicated and that learning did not take place.

Role of communication in instructional message design. Communication is the main component in instructional message design. The ability to adequately convey intended instructional content meaningfully for learners to understand is the goal of every instructional designer. Gutierrez (2013) reiterated that a message and intended audience are needed in communication. Feedback is crucial to successful communication between sender and receiver (Berko, 2007).

Learning problems may occur in education as a result of poor communication. Educational technologists perceive problems in learning as the result of ineffective communication (Bishop, 2014a). Early communications models relied on the way information is passed from one location to another, and have been characterized as transmission models (Richey, Klein, & Tracey, 2011). The communication process is not complete until the learner has fully understood the intended content.

Visual perception/perceptibility in instructional message design. How one's senses perceive and receive instructional content or information can go a long way in helping them understand the material better. According to Moore and Dwyer (1994), "perception is the gathering of information through our senses and the organizing of that information in order to create meaning" (p. 32). Gabrielli (2009) further explained that visual perception is, "the ability

to transform visible light stimulus reaching the eyes into information supporting recognition processes and action" (p. 3395). Pettersson and Avgerinou (2016) also mentioned that, "the concept of perception is a collective designation for the different processes in which an organism obtains information about the outside world" (p. 259). According to Gabrielli (2009), the Gestalt Laws of Organization state that six main factors determine how things are grouped in visual perception: proximity, similarity, closure, symmetry, common fate, and continuity. The ability to understand one's environment by handling information from one's eyes depends on external visual motivation, prior knowledge, goals, and expectations. Understanding how we all perceive things visually helps designers to effectively communicate instructional content. Gabrielli (2009) explained that, "the major problem in visual perception is that what is seen is not simple and always a translation of retinal stimuli (i.e., the image on the retina)" (p. 3396). The instructional message designer has to understand how the message influences the way that learners process instructional content. According to Fleming and Levie (1993), instructional message designers have to ensure that care is given to, "structural properties of messages that affect the perceptual organization. These include, but not limited to the relative placement, size and dominance of objects in the visual field and the way the eye is "led" over the image by various techniques of composition" (p. 56).

Ways of presenting a message/information

Messages designed for learner consumption are presented in different forms such as text (print typography and its heritage), maps, graphics (graphs, diagrams, charts, tables), pictures and photographic media, and visualization (video, animation, sound, computer interface design). The major components in instructional message design according to Petterson (2012) are words, visuals, and forms, which are important to produce meaningful content. An instructional message

designer should see intended information for learners as incomplete until learning has taken place. Legibility and readability of the content are essential for the readers/audience (Petterson, 2010). Chambliss and Calfee (1989) settled on three crucial elements for effective printed instruction. These are words or typography, soundness of the text structure that supports the organization and recall of information, and the correlation between a learner's background and the content.

Text design in instructional message design. When developing instructional text, the designers owe it to their readers to convey meaningful content and clear manuscripts for learners to understand. Armbruster (1989) identified five text structures that could be used to draw learners' attention to the relevant text. These are:

1. Simple listing - a listing of items or ideas in which the order of presentation is not significant.
2. Comparison/contrast - a description of similarities and differences between two or more things.
3. Temporal sequence - events connected by sequential relationships.
4. Cause/effect - an interaction between at least two ideas or events, one considered a cause or reason, and the other an effect or result.
5. Problem/solution - similar to the cause/effect pattern, except that the two interacting factors are a problem and a solution to that problem (p. 255).

Textual messages according to Bix (2002), involve the creation of words consisting of two cases, upper and lower, which are set in a particular font style. Common terms associated with text design include font and typefaces. A font comprises all of the letterings (upper and lowercase, figures, fractions, reference marks, etc.) of one size of one particular typography

(Craig, 1980). A typeface is defined as the full range of type sizes for the same design (Department of Mathematics, University of Utah, 2001). Typeface comprises all characters, in all sizes, of a particular design. The International Paper (1997) stated that typefaces are mostly available in 6- to 72-point [one point is equal to 1/72"], with a whole font in each size.

Features or attributes can enhance the communication of an instructional message by signaling the text structure to the learner. You can manipulate the text to point learners to essential areas within the text. One can use bolding, italics, and changes in type size to create a difference in the pattern of the page. The human eye is drawn to relevant words, and this can make a difference in understanding the content. According to Morrison et al. (2006), some factors to consider when using typographical variation are:

> First using too many variations on a page can overwhelm the reader making it difficult to see what is important. Second, the variation must be consistent throughout the material. Third, mixing of different typefaces or fonts on a page requires an understanding of concord and contrast in typography. (p. 179)

In addition to typographical variation to direct learners towards important content, Morrison et al. (2006) suggested that headings and layouts also point students to relevant text. Further, Morrison et al.(2006) stated that, "headings are keywords or short phrases that identify the content of the sections of text information" (p. 176). Use of headings to differentiate content is used for both printed and digital messages. When designing headings for instructional messages, one can use different levels of text. For example, the first level heading would correspond to Roman numerals I, II, and III, a second level heading could refer to A, B, and C, and a third level heading could correspond to 1, 2, and 3. Different font sizes could be used to differentiate the various levels of heading. The combination of boldfacing, uppercase, and italics

can change the message that is being conveyed. How the message is presented can highlight essential areas, show politeness, or demanding requests (Kostelnick, 1990).

Research conducted by Williams (2015) specified principles to follow when designing typography. Among these are leaving one space after punctuation - leaving two spaces after a sentence is a thing of the past. Williams (2015) also affirmed that it is advisable to avoid big spaces between sentences as it will interrupt the communication and make one's typed instruction look archaic and clumsy. The use of quotation marks in typing is one area where many people make mistakes. An opening quotation mark looks like two sixes (66), and closing quotation marks look like two nines (99).

Hartley (2004) suggested some typographical considerations in designing text. These include page sizes, margins, column width, type sizes, typefaces, capital letters, italicized letters, color, and spacing the text. Hartley (2004) further stated that the page size defines the visual display. How to determine the appropriate page size to use is crucial. How the information is going to be used must be considered in the design. Other considerations include reader preferences, the costs of production and marketing, basic paper sheet sizes, and the need to preserve resources and prevent waste (Hartley, 1994). Hartley went on to say that margins can be found in a written document and can sometimes take up to 50% of the page. A margin of 10 mm is typically used at the top and bottom of a page. However, if pages are printed on both sides of a page, 25 mm is recommended when one needs to bind the pages. Setting the right margin ensures that all the words in a page can be read clearly. Hartley (2004) explained that:

> Typical type sizes in textbooks are 10, 11, and 12 point. The "small print" (in legal documents, for example) may be 6 or 8 point, but this is too small for most people to read

with ease. Larger sizes (such as 14, 18, and 24 point) are used for headings and display purposes. (p. 919)

Different typefaces with the same selected type size may still differ in visible size. Thus, designers should carefully choose the appropriate typeface (Hartley, 2004).

Graphic Design. According to Schlosser and Simonson (2006), the term "graphics" is simply defined as "two- or three-dimensional images, typically drawings or photographs" (p. 102). Richey (2013) explained graphics in instructional design as, "a static pictorial, schematic, graph or chart and is often enhanced to direct the viewer's attention to certain information or to relate one piece of information to another" (p. 133). Graphic design is the ability to create a design on different mediums to satisfy the recipient. Graphic design is demonstrated by the signs you see in a store, book covers, flyers, mobile messages, and computer messages. According to Petterson (2012), graphic design is seen every day in the form of books, magazines, packages, papers, posters, symbols, and other products. The designer is required to ensure that the audience receiving the information clearly understands the material. Petterson (2012) explained that the goal of graphic design is to efficiently bring all the graphic elements together. The use of graphics in combination with text or audio information is a powerful way to present information for learners with different learning styles or interests, and to help them to grasp the message being communicated (Clark & Mayer, 2016).

Images, pictures, diagrams, graphs, maps and charts in instructional message design. Incorporating illustrations in a message has a role to play in helping learners understand the message. Illustrations such as pictures, charts and graphics are a crucial aspect of instructional message design (Anglin, Towers, & Levie, 1996). Pictures are defined as, "illustrations that have some resemblance to the entity that they stand for, while

nonrepresentational graphics, including charts, graphs and diagrams are more abstract but use spatial layout in a consequential way" (Winn, 1987, as cited in Anglin et al., 1996, p. 755). Felker, Pickering, Charrow, Holland, and Redish (1981) have stated that some examples of illustrations include photographs, drawings, diagrams, maps, and flowcharts. The use of illustrations helps to make a complex concept easy to understand. When communicating qualitative and large data sets, one should include maps, tables, charts, graphs, and diagrams (Fleming & Levie, 1993). Graphics devices such as maps can make it easier for learners to visualize and interpret content more easily. For example, using a map to illustrate weather conditions in a particular place. Also, it is easier to represent qualitative or quantitative results using tables rather than words. Felker et al. (1981) further advised that designers should use high-quality illustrations appropriately as needed to convey information that text alone cannot provide. This may keep the reader's interest and clarify meaning of the material. Design principles to keep in mind when adding illustrations to messages include:

1. Keep graphics simple, and don't include too many of them.

2. Label salient elements of the graphics, for example, provide a key and label the x and y-axis for a graph or chart where applicable.

3. Carefully explain all codes to ensure that the reader fully understands the illustration added (Felker et al., 1981).

Visuals complement text in a message by emphasizing the points made within the text provided. According to Petterson (2002), pictures convey a better overall meaning than words can. They can enable learning from text by enhancing comprehension and memory (Levie & Lentz, 1982). Pictures are useful when the content is new, important, and hard for readers to

comprehend (Petterson 2002). Zakia (1985) added that a picture can be used to persuade, flatter, tease, shame, and seduce audiences through advertisements. Researchers believe that the goal of visuals is to attract, gain, get, hold, and sustain attention (Petterson, 2002). Petterson further asserted that the purpose of pictures in design is to visualize, simplify, enlighten, draw attention, ease reading, explain, and carry meaning.

Audio in instructional message design. Another component of instructional message design is through audio instruction. According to Ferrington (1994), audio design is explained as the, "process of creating meaning through the use of aural imagery" (p. 1). With the increase in communication or education through the use of technology, audio instruction has become necessary in instructional delivery (Carter, 2012). Many institutions are incorporating audio (for example, podcasts) as a form of instruction. An instructional designer has to pay careful attention when designing audio instruction to ensure that they achieve their set goals. Since there are no other channels of information except sound, there is the possible risk of vagueness in instructional message design and interpretation (Crisell, 1986). As a result, sound audio design principles must be applied from the start. According to Ferrington (1994), the purpose of audio design is to secure learners in active listening. As the learners participate actively in audio instruction, they rely on the imaginative power of their mind to fully understand the designed instruction. Ferrington (1994) further stated that, "understanding the storytelling nature of audio and the power of the human imagination to generate mental images, is critical to effective audio design" (p. 1).

Creating audio instruction entails much more than simply plugging in a microphone and recording a voice reading some text. Instructional designers have to address four basic principles: 1) select the narrative format (informational, personal, or dramatic/poetic) appropriate to the

need, 2) the fleeting nature of spoken word and the implications to short-term memory, 3) the role of the environmental soundscape and how the listener processes the foreground, contextual, and background sounds, and 4) the difference between hearing and listening and why that distinction is important when creating instruction using audio (Carter, 2012, p. 57).

There few articles that have been published explaining how to make effective audio instruction. Therefore, more research is needed in the area of audio instruction (Carter, 2012). Further research conducted in this study also evidences the paucity of research in this area.

Animation in instructional message design. Animation is an exciting addition to picture illustration in instructional message design, and used mainly in computer-based instruction (CBI). According to Mayer and Moreno (2002), animation refers to a "simulated motion picture depicting the movement of drawn (or simulated) objects" (p. 49). Animation and other forms of graphics should be encouraged in CBI environments (Caldwell, 1980). One common use of animation is animated pictures. Schnotz and Rasch (2005) added that, "animated pictures can be used to support 3-D perception by showing an object from varying perspectives" (p. 47). Schnotz and Rash (2005) identified the uses of animation in instruction as directing learner attention to specific areas of the instructional content, showing dynamics of content, and allowing learners to explore learning through manipulating the object. This study also shows how the effects of using different animation strategies can affect audiences with varied prerequisite skills in different ways.

Animation can be an interesting way to present content to learners together with text and other message elements. However, contingent on how it is used, it may or may not stimulate learning (Mayer & Moreno, 2002). Instructional animation will be guided in the future by cognitive theory and research (Mayer & Moreno, 2002).

Video learning in instructional message design. Many researchers have recommended watching videos for learning purposes, and that this can increase learner motivation to ultimately promote learning. Though videos can cause learning to take place, other research has also indicated that lengthy videos can cause cognitive overload. As a result, video segmentation is required to guarantee that there is no cognitive overload. Cheng, Huang, Shadiev, Hsu, and Chu (2014) concluded that video segmentation reduces cognitive load and promotes effective learning.

Color in instructional message design. Another important area of instructional message design is the effective use of color and contrast to aid readability. Reynolds (2010) mentioned that color is a powerful visual stimulus in learning, and may be used to draw attention, refocus the eye, to categorize, to organize, create unity, and induce emotions. Color is used in instructional materials such as overhead transparencies, slides and filmstrips, motion pictures, and video programs (Pett & Wilson, 1996). Color contrast design is also very essential in CBI. According to Richardson, Drexler and Delparte (2014), color contrast is essential in eLearning and web design to foster learner retention without cognitive overload. Richardson et al. (2014) recommended that appropriate color choices be used to optimize contrast between text and background, using sans-serif fonts, minimizing visual complexity, using white space judiciously, and applying visual cueing cautiously to ensure that learners can read the content and maximize retention and transfer. Care must be taken when using color in instructional message design, as it must be suitable for the anticipated audience (Pett, & Wilson, 1996).

Message design for eLearning. Any form of learning which utilizes an electronic technology to access instructional material outside of face to face instruction is termed eLearning. This means that all the materials are available online, including student and teacher

communication. As with any form of instruction, guiding principles should be followed in designing the online content effectively. Many researchers have done work in this area. Prominent among the literature are Clark and Mayer's (2016) multimedia principles.

Clark and Mayer's (2016) multimedia principles were founded by evidence-based research practice for creating eLearning instructional materials. Multimedia can be explained as using varied forms of media to convey or communicate intended messages e.g. through text and visuals. According to Clark and Mayer (2016), there are eight multimedia principles that instructional designers can follow in order to design sound eLearning materials. The multimedia principles include: multimedia, modality, contiguity, redundancy, coherence, personalization, segmentation, and pre-training principle.

Mayer (2009) explains multimedia learning as presenting materials in words and pictures to ensure that learning takes place. Mayer (2009) further explains that by "words," he means that the material is presented in a verbal form which is printed or spoken text. By "pictures," he means pictorial forms which include using still graphics such as illustrations, graphs, photos, or maps, or dynamic graphics such as animations or video. Mayer (2013) further suggested that the goal of multimedia learning is:

> To minimize extraneous cognitive processing during learning (i.e., cognitive processing that does not serve the instructional goal), to manage essential processing during learning (i.e. cognitive processing needed to mentally represent the essential material), and to foster generative processing during learning (i.e., cognitive processing aimed at making sense of the material). (p. 395)

Multimedia learning is grounded in the fact that instructional messages should be designed taking into consideration how human mind works. This will likely lead to effective learning in comparison to instructional content that are not well designed.

Instructional message design principles applicable to devices used for mobile learning.

Mobile learning, in contrast to other forms of distance education, is unique. As such, guiding principles need to be followed carefully to ensure that instructional content is adequately communicated. Vavoula and Karagiannidis (2005) mentioned that with the advancement in mobile technology and the challenges it carries, care should be taken to design the content effectively. Principles serve as a basic truth that functions as the basis for a system of beliefs or conduct for a series of reasoning. According to Williams (2015), basic principles of design that appear in every well-designed piece of work are contrast, repetition, alignment and proximity (CARP). Instructional message design principles must add to the effectiveness and efficiency of the instructional message and clearly communicate the intended message.

Wang and Shen (2012) noted however, that the variety of mobile devices is the most challenging in content design. With these challenges in mind, mLearning designers should design the messages intended for mobile devices in an effective way to ensure that there's no cognitive overload. Wang and Shen (2012) further specified that:

> "Message design is analogous to the use of building blocks, with the whole picture being composed of smaller but well-specified elements such as language, images, signs and symbols. The goal of message design is to coordinate these elements so that they work together in our brains to provide better accessibility, usability and learning". (p. 9)

With the knowledge of how individuals learn in mind, designers can create course content that fits specific learner needs. As a result of differences in mobile devices, some

principles have to be adhered to when designing for different devices (Wang & Shen, 2012). Wang and Shen (2012) alluded to the fact that at present, there is a lack of research in instructional message design for mLearning. Further, current research has also indicated that there is a lack of published articles about how to design and implement mLearning:

> There are few resources published that offer comprehensive mobile lessons and concrete methods to effectively implement mobile learning into the classroom. Educators need specific guidelines and model examples of mobile lessons to fully understand how to create the lesson, what to consider when developing, and how to successfully integrate it into the Classroom (Vincent-Layton, 2015, pp. 149-150).

Shen, Wang, Gao, Novak and Tang (2009) also indicated that, "the best practices for using mobile devices in teaching and learning are still unknown. Systematic studies are needed to investigate student and instructor experiences with mobile learning" (p. 539). Wishart (2009) reiterated that, "considerable research is needed on how to design learning materials for delivery on mobile devices and what is the right mix of technology for distance delivery" (p. 279). Haag and Berking (2015) mentioned that, "Instructors, educators, and instructional designers are quickly adopting mobile technology in their learning environments, but strategic design considerations and proven pedagogical practices have not been systematically documented" (p. 42). The lack of design considerations for mobile devices could be because there are no established rules as far as which mobile devices are used for mLearning purposes (Haag & Berking, 2015). Furthermore, Huang, Zhang, Li and Yang (2012) stated that, "the quality of mLearning activity design, among other things, determines the quality of this new form of learning. However, few previous studies have touched upon how such design can be better undertaken to inform mLearning" (p. 9).

Though there is a lack of research on instructional message design for mLearning, researchers have identified some principles and recommendations to help designers when creating these courses for mobile devices. Keeping the variety of mobile devices and their attributes in mind helps designers to create messages effectively in order to satisfy different mobile users and ultimately achieve their goal irrespective of the type of mobile device learners have (high-end or basic mobile device). Table 4 highlights some of the principles for designing across varied mobile devices.

Table 3:

Principles for Designing for Different Devices

Principle	Explanation
Design for the least common denominator	Instructional content should be chunked and presented in multimedia messaging services or SMS so that all types of mobile devices can have access to information.
Design for eLearning, adapt for mLearning	Of all the mobile devices for mobile learning, PDAs are ideal for mobile learning because, they can easily be adapted to desktop computers.
Design short and "condensed" materials for smartphones	As a result of the small screens on mobile phone devices, "designers can focus on providing brief highlight or the summary of courses. Study guides, progress test reviews, notes, simple questions and answers, and other written content with pictures are also good choices." (p. 568)
Be creative when designing for mobile devices with 3G and 4G technologies	3G and 4G technologies now available for mobile phones enable designers of mLearning to incorporate videos and audio in mLearning. "These new wireless technologies offer a different way for users to connect with the public by phone. It also enables live video connections and makes higher capacity data transmission possible." (p. 569)

Note. Adapted from Wang, M., & Shen, R. (2012). Message design for mobile learning: Learning theories, human cognition and design principles. *British Journal of Educational Technology, 43*(4), 561-575.

Another important consideration when designing for mLearning according to Wang and Shen (2012) is the use of audio. An important attribute of mLearning is its mobility and flexibility. As a result of this, designers of mLearning should carefully consider audio to reduce noise and enhance communication. Because mobile devices have smaller screens, using the miniature keyboard is a hassle. To compensate, Wang and Shen (2012) have suggested that voice recognition could be utilized to either input data or give commands on these mobile devices. Automated speech recognition (ASR) can help to prevent strenuous repetitive manual input through standard size keyboards (Koester, 2004).

Including captions to enhance audio, video, text, and images is also an important consideration when designing mLearning. The use of captioning dates back to early filmmaking. This phenomenon is still relevant today with the use of handheld mobile devices (Downey, 2008). The use of captions compliments audio and text instruction through enabling designers of mLearning to communicate effectively to learners of all cultural backgrounds. Some captioning principles for mLearning include having one off-screen narrator and no pre-existing graphics, and including left-aligned captions at center screen on the bottom two lines. Single line captions should be center-aligned at the bottom, and three or four-line captions are acceptable if one or two-line captions interfere with the graphics and confuse the learner (Wang & Shen, 2012). Wang and Shen offer the following font captioning guidelines:

1. Characters need to be a font similar to Helvetica medium.
2. Characters must be sans-serif, have a drop or rim shadow and be proportionally spaced.
3. The weight must support a 32-character line.

4. The font must include upper and lower-case letters with descenders that drop below the baseline.
5. Pick a font and spacing technique that does not allow overlap with other characters, ascenders or descenders.
6. Consistency throughout the media is paramount.
7. The use of a translucent box is preferred so that the text will be clearer, especially on light backgrounds. (p. 572)

Color design principles for mLearning. The use of color in instructional message design is an important facet when designing instruction. Though the use of color in instructional content design does not necessarily increase learning, the right use of color does affect attention, search tasks, retention, and other measures (Dwyer, 1971). One can use color as a signal to facilitate learning (Pett & Wilson, 1996). Color is of value when considering how learners cognitively process content. This is specifically true when color is used to cue the salient points in the content (Pett & Wilson, 1996). Some color principles suggested by Wang and Shen include, using color to distinguish between elements, focusing on salient points, link related concepts, choosing consistent colors, and considering the age of learners receiving the content. They further suggest that designers use black backgrounds with high brightness colors, white backgrounds with low brightness colors, and moderate to high brightness contrast between symbols and backgrounds (Wang & Shen, 2012).

Audio design principles for mLearning. Audio design is another important aspect of mobile learning, as online learners engage with video, audio, and podcast content. Design principles are necessary to ensure sound audio content. However, there has been little research done in this area of design. As stated by Kim and Jin (2015), "although auditory information in

mobile learning (mLearning) can be an important resource for delivering knowledge and information, the importance of considerations for designing auditory instructions has largely been overlooked"(p. 60). Kim and Jin (2015) further reiterated that, "there has been no comprehensive set of validated practical guidelines to support designers in generating auditory instructions to supplement visual objects in both textual and non-textual m-learning lessons, which run on small-screen mobile devices, such as cell phones." (p. 61)

Kim and Jin (2015) recommend the following auditory design principles, which were grouped into three categories: auditory only design, attention design, and personalization design.

Table 4:

Audio Design Principles

Design	Design Principles
Auditory only	• Explain all non-text objects (tables, graphs, photos etc.) included in the mLearning content. • Avoid pauses that are more than 3 seconds long when explaining the learning content. • Provide an auditory only function
Attention	• Provide an attention attracting message when the learners do not respond to instruction for a certain amount of time. • Design to automatically stop the learning content explanation by sub-topic or by logical point and play when any button on the mobile device is pressed. • Explain the important information louder, slowly, or repeatedly (2-3 times). • Provide a cue sound when a learning topic is switched or learning begins or ends.
Personalization	• Provide control options to block incoming calls and texts. • Provide an alarm function that informs the learner of the learning time for the m-learning content that the learner specifies. • Explain the important information louder, slowly, or repeatedly (2-3 times) • Provide a sound playback configuration function to change the speed..

Note. Adapted from Kim, T. H., & Jin, S. H. (2015). Development of auditory design guidelines for improving learning on mobile phones. Computers & Education, 91, 60-72.

Addressing the Need

Learning is essential in our personal as well as our professional lives. Learners today are encouraged to be active in their learning, self-thinking, and to be active consumers of knowledge (Bunce, Baird, & Jones 2017;Crompton, 2013). Mobile learning has become very popular. Though it is a young field, it became widely used and recognized in the 2000's when tablet computers became popular. The primary focus of mobile learning can be narrowed to three major aspects as seen in most of the definitions. These are devices, learning outside the classroom, and learner mobility. Given the characteristics of mobile devices used for mobile learning, such as size and portability, there is a need to design messages and instructional materials effectively to ensure that learning takes place. Learning may be done by applying instructional message design principles to content in order to prevent cognitive overload.

There is a huge potential and future for mobile learning, "the future adoption of mobile learning and the success of such efforts requires continuous awareness and integration of new technologies and functions" (McQuiggan et al., 2015, p. 333). Research conducted so far shows that mLearning is here to stay and the momentum it has taken will keep accelerating. Mobile learning is known and used in developed as well as developing countries. McQuiggan et al. (2015) added that, with the introduction of the iPad and tablet devices, mobile learning will continue to grow at a quicker rate. Mobile learning is expected to continue to grow exponentially. Hanbridge and Sanderson (2018) state that, "it is anticipated that mLearning will grow quickly in the next few years" (p. 119). In conclusion, "we should not view communication as complete until the intended receivers understand their intended messages as these were originally meant by the information designer/sender" (Petterson, 2016, p. 265). This will require

content developers to follow empirical based research principles to ensure the right amount of cognitive load.

Chapter Three

Research Methodology

Introduction. This chapter examines the research methodology employed in the study. This study utilized the design and development research approach, and is based on multimedia principles (Clark & Mayer, 2016), universal design principles (Center for Universal Design, 1997), and mobile interface design best practices (see Appendix A). This study proposed considerations that these principles should be utilized to guide instructional message design for mLearning.

Considerations were proposed for mLearning instructional message design, and specifically for mobile phones. A literature search showed that very little empirical research has been conducted in the area of instructional message design for mLearning. As such, this study seeks to close that gap. The research investigated instructional message design principles for multimedia and universal design principles and their application to mobile learning. This resulted in a set of recommendations useful to creators of instructional content for mobile phones.

Study Design. This study employed a design and development method of research. Design and development, as defined by Richey and Klein (2007) is, "the systematic study of design and development and evaluation process with the aim of establishing an empirical basis for the creation of instructional products and tools and new or enhanced models that govern their development" (p. 1).

Design and development research address two different types of inquiry: product and tool research (formally known as Type One), and model research (formally known as Type Two). The proposed study employed product and tool research. This type of research, according to Richey and Klein (2007), is conducted by making a product or tool. Tool development research

includes all of the certification processed leading to the production of an instructional or non-instructional tool (Richey & Klein, 2007). Richey and Klein (2007) defined model research as it, "pertains to studies of development, validation, and use of design and development models" (p.10). The purpose of model research is examining models in order to generate new knowledge (Richey & Klein, 2007). Seels and Richey (1994) described developmental research as, "the process of translating the design specifications into physical form" (p.35). Richey and Klein (2007) also defined developmental research as, "the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development" (p. xv).

Design and development research make use of different types of qualitative and quantitative methodology such as case studies, interviews, document reviews, observation, and experimental designs among others (Richey & Klein, 2007).

To address concerns regarding areas of validity, causal inferences, generalizations and interpretation, and anticipation of problems in this type of study, Richey and Klein (2007) have recommended the following strategies be used in the conducting the study.

1. To address validity, experts with differing areas of specialization should be used for tool review.
2. Causal Inferences can be addressed by relating tool attributes to learner behaviors To determine the tools practicality and effectiveness.
3. To allow for generalization and interpretation, conduct usability analysis, recognize real world constrains and independent use of the tool.

4. Anticipate problems that may affect the use of the too. (pp. 58 – 60)

Characteristics of Expert Reviewers. To enable one to obtain accurate feedback, specific criteria should be followed in selecting expert reviewers as suggested by Richey and Klein (2007). Expert reviewers provide objective assessment for the created considerations in design process. They can provide insight into short-term improvements, long-term direction, and considerations as a whole. Identified expert reviewers should have at least one of the following characteristics. Given these factors, expert reviewers for the study must be knowledgeable in at least one of the following areas: online learning, distance education and/or eLearning, and universal design of learning/accessibility of online content and mobile interface design. The expert reviewer should be well-informed about current research and should have experience facilitating or designing mobile learning for instructional purposes. They should also be experienced in designing for varied forms of media and using principles of design for mobile phones. Since the considerations were developed from a perspective of learning and accessibility, knowledge in universal design of learning and assistive devices is of high importance. Experience in mobile phone user interfaces and user interface design is key. Expert reviewers should also have at least two to three years of experience as a researcher, designer, or facilitator of mLearning.

The expert reviewers were recruited mainly via email (Appendix B). The email explained the purpose of the study and the importance of their involvement. The researcher obtained approval for the study from the Institutional Review Board (IRB) at Virginia Tech.

Instrumentation. The survey for the expert reviewers was created using Google Forms survey software (see Appendix H). It consisted of three sections and 27 questions representing the specific guideline categories and validity factors (Richey & Klein, 2007). Section One

focused on the general overview of the considerations, and included a yes/no question to provide consent. This allowed the reviewer to move forward to answer the survey questions. Section Two of the survey focused on obtaining data about specific areas associated with the considerations. These included general design, design for function, text, color, video and audio, and graphics. Section Three emphasized the elements of valid design and development research recommendations. These validity indicators included: effectiveness, practicality, generalization and interpretation, and anticipating problems with guideline use. The survey questions were based on the recommendations provided by Richey and Klein (2007) and the specific guideline sections. Sections of the expert review survey inquired about the clarity of individual guideline categories, and asked for any suggestions to improve them.

Section Three focused on the validity of the considerations as suggested by Richey and Klein. The survey included eleven questions aimed at providing evidence to verify the validity of the considerations. Two questions each represented the practicality, effectiveness, and real-world constraints affecting use. The first question provided check boxes allowing reviewers to select indicators to determine guideline practicality. The next question inquired about how they would evaluate the overall practicality of the considerations, and finally, any suggestions they had to improve the practicality of the considerations. The next three questions within Sections Three and Four were dedicated to the effectiveness of the considerations. Again, reviewers were asked to select indicators of the guideline's effectiveness, the overall effectiveness, and to provide suggestions to improve effectiveness. Next the survey questions focused on the extent to which real-world constraints could affect the use of the guideline. The final question asked if the considerations could be used independently of one another, and included an open-ended question

for suggestions to improve the considerations. Different question types were included in the survey. They included multiple choice, descriptive text, Likert scale, and checkboxes.

Study Procedure

The study employed three phases in its delivery. The first phase (analysis stage) was to identify design principles. This involved a literature review of instructional message design principles (multimedia principles), universal design principles (universal design of instruction), and best practices for mobile user interface design. The second phase (development stage) involved taking the findings from the research and formulating a set of principles. This was achieved through synthesizing Clark and Mayer's (2016) multimedia, universal design principles and mobile user interface design best practices. In the third and final (evaluation and revision) stage of the study, feedback and recommendations were gathered from five expert reviewers and revisions were made to the considerations. Virginia Tech IRB approval was obtained before formal emails were sent to recruit potential reviewers. Phase Three included revision and evaluation of the considerations. After IRB approved the study, emails were sent to seven expert reviewers explaining the study and five of them responded. Upon acceptance to participate in the study a follow-up email was sent which included specific instructions on how to access materials and participate. This email (Appendix B, E) also detailed the procedures and a link to the website for the considerations. An online survey was created, and principles were identified to allow reviewers to provide needed feedback. The first section of the online survey dealt with the informed consent (Appendix D) and provided an opportunity to proceed or opt out of the study. The informed consent was included in the website so that reviewers could read it and ask questions before participating in the study. The third and final phase (evaluation phase) consisted of providing recommendations based on the expert reviewer feedback. This resulted in revisions

to the principles for designing for mobile learning for designers and developers of mLearning. The considerations developed, along with the survey, were made available to the five expert reviewers with varying expertise and areas of interest pertaining to the study. Based on their feedback, recommendations and revisions were made to improve the considerations.

Phase one - analysis phase. The analysis phase is the most important phase to start any study, as demonstrated by the analysis, design, development, implementation and evaluation (ADDIE) model. The ADDIE model captures the process of design which include analysis, design, development implementation and evaluation of services processes or products. The analysis phase is conducted before the task at hand (course development or research) is conducted. In line with Analysis within the ADDIE model, it is essential to identify what the literature contains regarding instructional message design principles for mobile devices. It is also important to determine the best practices for mobile interface design. This phase of the research began with a thorough analysis of the literature on principles of instructional message design for mobile devices and best practices for mobile interface design. This helped to focus the research upon which the considerations were developed. The literature review investigated areas such as instructional message design principles for mobile devices, considerations for information design, multimedia principles, instructional message design principles, universal design principles, empirical studies in instructional message design, and best practices for mobile interface design.

Phase two - development. According to Richey and Seels (1994), "development is the process of translating the design specifications into physical form" (p. 35). The application of techniques and technology into the production of a product or tool is a way to bring alive what a researcher has planned and designed. This gives the researcher a prototype for evaluation with

which they may improve the product or tool (considerations). One can accomplish that by selecting available materials, modifying existing materials, or designing new materials to help accomplish a specific task (considerations). This is when all the work comes together and can be shared with others. In the development stage, findings from the extensive literature search were used to develop considerations for designing messages for mobile phones. This was achieved by operationalizing Clark and Mayer's (2016) multimedia principles, universal design principles, and best practices for mobile device user interface design. Expert reviewers provided important feedback focused on the considerations. Both the survey and the considerations were made available to three expert reviewers for data collection.

Phase three - revision and evaluation phase. The revision and evaluation phase involved reviewing the data collected from the five selected expert reviewers, and incorporating their recommendations. This resulted in revisions to the principles for designing mobile learning targeting designers and developers of mLearning. Revisions to the considerations were made based on the suggestions of expert reviewers. As mentioned earlier, five expert reviewers were sought for in this study. Expert reviewers were identified based on expertise with instructional message design principles for designing for mobile phones, mLearning, universal design principles, multimedia learning, mobile learning, learning and cognition, and designing effective instruction for the purpose of learning.

The five expert reviewers were given a set of considerations developed from Clark and Mayer's multimedia design principles, universal design principles, and mobile interface design best practices. A survey was created and made available to reviewers to help guide the feedback. Criteria were used during the selection process to ensure that all relevant guideline areas received expert review. Expert reviewers looked at the considerations developed and provided feedback

through the online survey. Recommendations from the expert reviewers were collected, then the considerations were revised based on their feedback.

Data Sources

This study encompassed a search of the literature to determine which principles existed for designing for mobile phones and eLearning. After a careful search of literature, this study utilized multimedia principles and universal design for Instructions (UDI) principles, mobile interface design best practices, and proposed considerations for designing instructional messages for mobile phones. The Clark and Mayer (2016) multimedia principles are comprised of eight principles of multimedia, and are based on cognitive theory, cognitive load theory, and information processing theory. In sum, people learn better when the instructional design aligns with how the human mind works. Clark and Mayer's (2016) multimedia principles were chosen because their research provided evidence-based considerations on how to best present content with text, graphics, and audio for eLearning. Multimedia learning combines at least two different forms of media (text, graphics, animation, audio, or video) to produce content that learners access via the internet (Mayer, 2001). Since instructional message design for mLearning also combines different media for instruction, these principles were explored to investigate how they apply to instructional message design for mobile phones. Table 7 details the multimedia principles.

Table 5:

Clark and Mayer's Multimedia Principles

Principle	**Meaning**
Multimedia Principle	Building a connection between verbal (the written words) and pictorial representations (graphics, animations)
Modality principle	The mode of presenting media for a variety of content
Contiguity Principle	Contiguity involves the need to coordinate printed words with corresponding graphics
Redundancy principle	Eliminating various forms of redundant information within the instructional content
Coherence principle	Avoid adding extraneous material, which is not included in instructional goals
Personalization principle	Encourage more conversational style rather than a formal style in both text and audio narration
Segmentation Principle	Breaking a continuous lesson into manageable segments
Pre-training Principle	Ensuring that learners are familiar with key concepts

Note. Adapted from Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction*: Proven guidelines for consumers and designers of multimedia learning (Fourth ed.). Hoboken: Wiley.

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It is important to also look at designing instruction that are inclusive, meaning that everyone partaking in instructional content will benefit from it. According to Burgstahler (2012), universal design for Instruction (UDI) centers on this inclusion rather than designing for the average

student. This should include "persons with a variety of ethnic and racial backgrounds, average students, and other potential students within a broad range with respect to ability, disability, age, reading level, learning style, native language, race, and ethnicity" (Burgstahler 2012, p. 1). In this study, universal design principles as prescribed by Center for Universal Design (1997) that include equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance and error; low physical effort; and size and space were also adopted.

The purpose of applying the UDI principles in designing instruction is to, "maximize the learning of students with a wide range of characteristics by applying UDI principles to all aspects of instruction (e.g., delivery methods, physical spaces, information resources, technology, personal interactions, assessments)" (Burgstahler, 2012, p. 1).

Another crucial data source for this research is the literature review on best practices for mobile user interface design. Since the purpose of this research is to develop a set of considerations for designing for mobile phones, there is the need to look at principles of interface design for the device itself. This helps in making informed decisions about how to design effective instruction for mobile phones. Best practices for mobile interface design were gathered from various researchers. Pooling the resources for both interface design and instructional message design principles is the best way to ensure that the most important component factors are taken into consideration. A compilation of best practices for mobile interface design can be found in Appendix A.

Data Analysis

Data was collected from five expert reviewers based on the considerations created and an online survey. The data collected from the literature review was used to guide the initial considerations for instructional message design for mLearning principles. Data collected from

experts was carefully analyzed to establish and revise principles for designing instruction for mobile phones. A review of the feedback from expert reviewers was conducted, and recommendations were provided to improve the initial considerations.

Chapter Four

Developing the considerations for Instructional Message Design in Mobile Learning

Introduction

Instructional designers, content developers, and teachers of mLearning need comprehensive considerations when designing for mobile phones. Richey and Klein (2007) highlighted the significance of detailing all the processes leading to the production of instructional and non-instructional tools. This study focused on the design of instructional considerations to determine the application of Clark and Mayer's (2016) multimedia principles, mobile interface design best practices, and universal design for Instruction principles and how they are applicable to designing instruction for mobile phones.

Chapter Four presents the findings from a broad literature review conducted during the analysis phase, together with the considerations development process for designing content for mobile phones. It describes the development and evaluation process used in the creation of a set of considerations for designing instructional content for mobile phones.

Guideline Development Process

The guideline development process involved four steps. Steps included: analysis of the literature and framework, formulating the considerations, preparing survey questions for expert review, and organizing resources together in a website for easy access. These resources included the background to the study, considerations, informed consent, and the expert review survey.

Step 1: Literature analysis and specifying framework. The guideline development process began with a comprehensive literature review of relevant topics pertaining to the research. Webster and Watson (2002) explained that a, "review of prior, relevant literature is an essential feature of any academic project. An effective review creates a firm foundation for

advancing knowledge, it facilitates theory development, closes areas where a plethora of research exists and where research is needed" (p. xiii). The importance of doing a literature review is essential as it uncovers the knowledge gap and informs the study. The essential literature review areas covered for the study included instructional message design, principles for designing for mobile learning (mLearning) (specifically mobile phone), universal design principles, and mobile interface design. Webster and Watson (2002) further affirmed that a complete review covers relevant literature on the topic, and is not restricted to one research methodology, one set of journals, or one geographic area. As a result, the review took a varied approach with sources including databases such as Education Research Complete EBSCO host, Jstor, ERIC from EBSCOhost, eBooks, inter library loan services, ILL, physical books, Virginia Tech summons, Computer and Information Systems Abstracts from ProQuest, and Computers & Applied Sciences Complete from EBSCOhost.

As mentioned in Chapter Two, little work has been focused on instructional message design for mobile learning(mLearning). This study investigated and formulated considerations in developing content for mLearning, specifically for mobile phones. The considerations were created from a learning and accessibility perspective. Since we want to ensure that students have access to intended relevant content, it is important to address the considerations both from a learning and accessibility standpoint. As mentioned in Chapter Three, the study used Clark and Mayer's (2016) multimedia principles, universal design principles, and mobile interface design best practices. Some search terms used in the research process included:

- Designing the mobile interface
- Principles of mobile interface design
- Best practices for mobile interface design

- Designing content for mobile phones
- Designing eLearning
- Pedagogy for a digital age
- Designing the mobile interface
- Designing hand held devices
- Designing the user interface - strategies for effective human-computer interaction
- Designing the mobile interface
- Delivering eLearning
- Multimedia learning
- Mobile learning

A great deal of careful thought went into choosing the articles that were most relevant to the study. Webster and Watson (2002) suggest an ideal article should motivate the research topic, describe the key concepts, outline the boundaries of the research, review relevant prior literature, develop a model to guide future research, justify intentions, and present concluding implications for researchers and managers. These considerations directed the choice of resources used to develop the considerations.

Step 2: Formulating the considerations. Based on the findings from a thorough search of the literature, the considerations for designing mobile content were created. The considerations resources for designing mobile content for online learning are shown in Appendix F. The initial considerations (Appendix G) were built with the intention of enabling instructional designers, content developers, instructors, and researchers to guide quality content development for mobile learning.

The guideline formulation included a four-step process.

- Analysis of relevant literature
- Grouping relevant literature
- Categorizing guideline resource sections and filling in categories
- Organizing suggestions into meaningful categories

Analysis of relevant literature. Literature that was gathered for the study was carefully analyzed to determine relevance to the guideline development process. This was achieved by searching for articles closely related to the relevant areas needed for the study. The articles, books, and other resources were critically evaluated for any recurring ideas. This was done my using themes which may be inferred or subtle. Each of the articles were read, and the key areas of interest and relevance to the research were noted. Key areas included principles and their meanings, empirical studies supporting each principle, applicable mobile interface design best practices, and any other content areas needed for the considerations.

Grouping relevant literature. After analyzing the relevant literature, each of the articles and resources were grouped into multimedia, universal design and supporting literature for multimedia and universal design principles. The purpose of this engaging in this activity was to organize ideas to ensure that resources for each classification were easily accessible once the guideline building process began.

Categorizing guideline resources into sections and filling in classifications. After grouping the relevant literature, sections were categorized for inclusion in the considerations. After careful thought, four main categories were identified. These included statements of the principle, explanations of the principle, supporting literature, and how to operationalize considerations for designing for mobile phones. These four categories simplified the resources for easy understanding and interpretation. After identifying the categories to use, the information

gathered during the literature grouping stage was used to fill in the relevant information for each classification. The final stage of categorizing the resources was to operationalize the considerations for designing for mobile phones based on the evidence presented. At this stage, thought went into the challenges of mobile phone use and how the principles might be applicable for designing content. These were stated in simple and easy to understand terms so that content developers and instructors could easily conceptualize how the principles could be used in the mobile phone content development process. The research findings were categorized into four sections. Section One highlights the principles used in the study, Section Two includes explanations for the principles listed in Section One, Section Three summarizes the supporting literature for each of the principles, and Section Four describes how to operationalize in designing for mobile phones.

Organizing suggestions into meaningful guideline categories. Following the operationalizing process, suggestions were organized for ease of guideline use and functionality. Thought went into how best to categorize these suggestions to fit the study. Upon careful consideration, the following categories were chosen to organize the suggestions: general design principles, designing for function, text, video and audio, animation, graphics and color. These categories made sense as they described the various instructional message design elements used when designing content for mobile phones. These categories certify that all aspects of design have a principle to follow. The general design principles and suggestions for designing for function were stated first so that designers could easily access them if they needed to design specific content. The next step was to look at the specific area you are designing for suggestions. Considerations can be found in appendix F.

Step 3: Formulation of survey questions for expert reviewers. As mentioned earlier, the considerations utilized Clark and Mayer's (2016) Multimedia Principles, Center for Universal Design's (1997) universal design for instructions, and mobile interface design best practices. The survey was used by expert reviewers as a rubric to record their suggestions and feedback. Recommendations were then provided for the "Considerations for designing content for mobile phones." The survey was divided into three sections. The first section focused on the introduction to the study and consent to move forward with answering the survey questions. The next section was dedicated to the specific guideline categories for designing content for mobile phones, and the last section focused on the practicality, effectiveness, independent use, and real-world constraints that may affect content design for mobile phones.

The third section of the survey questions were formulated based on Richey and Klein's (2007) recommendations, and specific questions were also devoted to the considerations based on the suggested categories. The validity of a tool or guideline is, "in large part through rigorous application for the design and development processes and of the manner in which products or tools are implemented" (Richey & Klein, 2007, p. 57). Richey and Klein (2007) suggested four representative research design techniques used in product and tool research, and specifically for tool development and use. These included validity, causal inferences, generalization and interpretation, and anticipating. To ensure the considerations are valid, one should include differing areas of expert specialization, and different levels of expertise should be recruited to test the tool (Richey and Klein, 2007). Further, a causal inference concern could be addressed if the tool is related to the attributes of learner behavior, tool practicality, and effectiveness. To address generalization and interpretation problems, they suggest to recognize real work constraints on tool use and plan accordingly. Finally, anticipation problems should be addressed

by building data functions within tools and considering cultural norms when analyzing student data. Some of the survey questions were designed to assess the effectiveness of the categories which included general design principles, designing for function, adding text, graphics, captions, animations, color, and video and audio. The intent of adding these classifications was to verify the usefulness of the categories included in the considerations.

Based on the recommendations provided, the survey questions were designed to receive the correct type of feedback for guideline revision, and to address the concerns mentioned in the suggestions above. The researcher used Google Forms to design the survey questions. Altogether, the survey included 16 questions dedicated to specific guideline categories, and 12 devoted to practicality, effectiveness, independent use, and real-world constraints. The questions included were of different types including multiple choice, grid or Likert, checkbox, descriptive, and drop-down menu type questions.

Step 4: Organizing guideline resources. A website was created to house all the guideline components. This step was included to collect everything in one location instead of having multiple documents. The rationale for this approach was to allow reviewers access to all the documents and information needed to provide feedback. The website was created with Google Sites and was organized into three sections: home page, Institutional Review Board (IRB) informed consent, and considerations. The home page section provided a broad overview of what the dissertation was about. This document provided the background and purpose for the study to give reviewers a better understanding of the research. Next the researcher included the IRB informed consent. Reviewers were required to read and provide their consent before proceeding to answer the survey questions. The informed consent form included 13 items explaining the details of the study and the possible consequences of partaking in the study.

Reviewers were asked to ask any questions or voice concerns prior to participating in the study. Finally, the considerations section of the website was devoted specifically to the purpose of the study. This section was categorized into four parts: an overview of the considerations, sample of the considerations, guideline resources, and the survey questions.

Conclusion

The considerations were developed using principles from a learning and accessibility standpoint by focusing the research on multimedia principles and how they could be operationalized for designing content for mobile phones. The research considered the principles, their meaning, supporting literature, and how to operationalize the findings for mobile phones. This research included searching for evidence-based content that supported the principles. Another focus was on mobile phone user interface best practices, and which were applicable for each of the nine multimedia principles. The study also focused on accessibility when designing course content for mobile phones. The accessibility considerations were centered on the universal design principle, explanations of the principle, supporting literature, and how to best operationalize design for mobile phones. Finally, the research also took into consideration the best practices for mobile interface design.

Empirically designed considerations for mobile phone content design can be very beneficial in promoting effective instruction. Instructional designers can use these principles when designing any form of instructional content since any learner may potentially access content via mobile phones, especially in an online environment. The development of the considerations required an identification of necessary elements based on prior research as well as several iterations of the guideline elements. This included the definition of the principles, relevant literature, and how to operationalize them in designing for mobile phones. The steps

outlined in this chapter helped to produce considerations that may be useful for content developers, instructional designers, students and faculty of instructional design, and development areas of specialization.

Chapter Five

Results

This chapter presents a report of the expert reviewer recommendations for determining the effectiveness of the considerations for designing instruction for mobile phones. This chapter presents a summary of the research, the reports from expert reviewers who participated in the study, overall expert reviewer perspectives, and specific recommendations identified through expert reviewer contribution.

Review of the Considerations

The considerations were created from a learning and accessibility stance, and utilized Clark and Mayer's (2016) multimedia principles and universal design of instruction. Since the considerations were designed for mobile phones, the research also took a look at mobile interface design best practices and how they were applicable to designing for these devices. As part of the design and development research, validity was evaluated by experts with varied expertise related to the use and purpose of the considerations. Diverse experts were sought for the study. Seven experts from different fields and with varied expertise received the invitation to participate in the study, with five responding (71.4%) and agreeing to participate in the study. Below are the profiles for the five experts who agreed to participate in the study:

Dr. M. J. Bishop is a Director for the William E. Kirwan Center for Academic Innovation at the University System of Maryland. Dr. Bishop is the inaugural director for this Center, which researches best practice, distributes information, and offers professional development opportunities for faculty and administrators. She is an expert in instructional media and delivery systems to ascertain academic capabilities and limitations, and in devising effective ways to design technologies to enhance learning.

Dr. Mike Sharples is an Emeritus Professor of Educational Technology in the Institute of Educational Technology at The Open University, United Kingdom. His research involves human-centered design of new technologies and environments for learning. Dr. Sharples's research focuses on adapting and developing new technology and socio-technical systems to facilitate learning, such as the use of mobile devices. He has done extensive work in the area of mobile learning research.

Dr. Douglas Bowman is a Frank J. Maher Professor of Computer Science and director of the Center for Human-Computer Interaction at Virginia Tech. He is the principal investigator of the 3D Interaction Group, focusing on the topics of three-dimensional user interface design and the benefits of immersion in virtual environments.

Dr. Marc Zaldivar earned his doctoral degree in Instructional Design and Technology from Virginia Tech. He is the director of Networked Learning Initiatives, Curriculum and Assessment. Since 1993, he has focused on transformative education, as well as language and critical reading/writing skills. He joined Technology-Enhanced Learning and Online Strategies and began to direct the ePortfolio Initiatives at Virginia Tech, focused on large scale deployment of student-centered learning technologies.

Dr. Tara Jeffs is a leading practitioner in the field of Assistive Technology (AT) and the universal design for Learning and Technology Coordinator supporting AT specialists. Dr. Jeffs is an assistive technology specialist for Loudoun County Public Schools in Ashburn, Virginia. Her career in education spans over 40 years, and started with teaching math and science to students with learning disabilities at the high school level. Her PhD focused on Assistive Technology, and she graduated from George Mason University.

Following approval from Virginia Tech's Institutional Review Board (IRB), a recruitment email was sent. Of the seven experts requested, five agreed to participate in the study. A follow-up email was sent to the participating experts detailing the guideline website, and how to use the resources. Expert reviewers were encouraged to read the overview of the study, IRB informed consent, the considerations, and survey. The experts were asked to review the survey within a two-week period. Two reviewers responded within the first two weeks. After the original two-week timeframe was over, a reminder email was sent, and another week was proposed to complete the review, the remaining reviewers responded.

Google Forms was used to collect the data/recommendations from expert reviewers. A total of 25 questions were included in the online survey. These survey questions were divided into two sections. Section One included 14 questions targeting specific sections of the considerations including general considerations, design for function, text design, color design, graphic design, animation design, and video and audio design. Section Two targeted practicality, effectiveness, real world constraints, and independent use of the considerations. Closed-ended questions were included to enable experts to provide their viewpoints on specific parts of the guideline. Open ended questions were also included to provide experts with the opportunity to provide suggestions to improve the considerations. The following section presents expert reviewer feedback to the survey and open-ended questions. The order at which they are presented does not reflect the identity of the reviewer.

Overall Expert Reviewer Perspective

Overall, experts agreed that the considerations would be helpful to instructional designers and content developers, and specified recommendations to help to make the considerations even stronger. Four out of five reviewers strongly agreed or agreed that the considerations, when used

by content developers, are likely to effectively improve the quality of mobile learning in distance learning experiences. Three of the experts (three of five) also agreed that the organization of the considerations supported their purpose and use. One of the two experts who did not agree stated that, "You have a great start - with a little tweaking and closely embedding accessibility considerations and using conversational language could make one's considerations very useful. I would suggest you add or look closely at Instruction and the UDL considerations for learning…" Another expert suggested, "I think the current format is OK but see my specific suggestions on refactoring and combining some of the categories. I think you want the categories to be non-intersecting, and the titles of the categories should clearly indicate where I should look to learn about considerations on a certain topic." While general support for the overall design was given, reviewers provided feedback for revision of the considerations.

Recommendations from Expert Review

General design principles. When asked if the considerations provided for Section 1: General Design Principles, were clear and easy to understand, four out of the five experts strongly agreed or agreed. One of the reviewers had a neutral stance on this question. Some of the experts also provided additional suggestions to improve the general design principles considerations. Reviewer One stated that:

> "It would be good to show examples of good practice alongside the considerations. Perhaps you could consider more the contexts in which mobile content will be accessed - for example, outdoors in bright sunlight, on a rainy day, on a noisy train, in a quiet museum or library. It's not possible to design for all mobile contexts, but it's important to consider the main ones (e.g. outdoors in sunlight)."

Some examples for how these considerations would be used were incorporated as was suggested. The second half of the suggestions will be something for future study, and are outside of the scope of the current study. Reviewer Two also provided the following response when asked how to improve the general design considerations:

> "2nd guideline: I'm not certain from the wording whether this is referring to simplicity of content or simplicity of format.
>
> 4th guideline: Speech *input* is not a content *presentation* method. Do you mean that content can be presented with speech audio, or that learners can navigate the content or interact with the content via speech? If the latter, you may need to link to some examples of how to do this effectively, since most mobile content does not use speech input.
>
> 6th guideline: It would be nice to link to some examples of how to use SMS in mobile learning."

The same sentiments were suggested by Reviewer Four who stated that, "If they will stand alone, then I think they would be strengthened by providing examples and, perhaps, even screen shots that explain one's meaning further." These suggestions were incorporated to make the considerations stronger. Reviewer Four further suggested, "Also, for ease of reading and clarity, I suggest they be written consistently throughout in terms of sentence structure (start with a verb, for example). This suggestion was also incorporated into the considerations for consistency.

Designing for function. When asked if the considerations for designing for function were clear and easy to understand, all five of the experts strongly agreed or agreed that the considerations for designing for function were clear and easy to understand. Reviewers also provided suggestions to make this section of the considerations better. Reviewer One stated that,

“Design for context - e.g. accessing and responding to content while walking (make buttons easy to click use with one hand). Some general HCI principles are even more important with mobile, e.g.: Provide a single click back to a home page. Offer an 'undo' facility.” This was incorporated in the considerations as seen in Appendix L.

Reviewer Two also provided suggestions to improve the design for function category, stating that, “the category title ‘design for function’ implies to me that this section will contain considerations for the interactive functionality or features of the mobile learning site/app/tool (i.e., activity design and interaction design). But many of these considerations are about content presentation (i.e., information design).” Reviewer Two expanded upon this mentioning that the first seven considerations in this section fit in the "design for function" category, but the rest did not. Reviewer Two stated, “Perhaps you could reclassify the considerations in the first two categories (general, design for function) into three sections (content design, content presentation, and functionality).” This suggestion was incorporated into the considerations to further clarify for users. Reviewer Three alluded to the fact that multiple formats in the considerations were listed twice, and that they should be stated once with more detail. This was also integrated into the considerations. Reviewer Four’s recommendations mainly focused on the specific considerations related to how to design for mobile interfaces. These are outside of the scope of the study. Reviewer Five also emphasized the that the strategy of one idea per screen should be fixed so that formats appear once with better explanation. This was reflected in the changes made to the considerations.

Adding text. When asked if considerations for adding text were clear and easy to understand, all five of the expert reviewers strongly agreed or agreed that the considerations were clear and easy to understand. Four of the five of the reviewers provided further suggestions

in order to help improve the text design principles. Reviewer One suggested, "Keep sentences short. Try not to put more text than can be read on a single phone screen. Use large font size. Check text for readability (e.g. with the Microsoft Word readability check)." This suggestion was also reflected in the additions/revisions made to the considerations. Reviewer Two added:

> "Avoid adding extraneous material" is a repeat of a guideline from the general category. "Sans-serif" is misspelled. You might consider adding a guideline about making text as concise and focused as possible. On the smallest mobile phones, very little text can appear on the screen at once, so it would be good to write the text so that a complete idea can be seen on the screen without scrolling.

This suggestion was reflected in the changes made to the considerations. Reviewer Three asked if the font type for the considerations was sans-serif as the requirement for easy readability, according to research, is for online text to be sans serif. This suggestion will be added to the consideration's website at a future date. The final recommendation in this category was provided by Reviewer Five:

> You do not address some of the accessibility barriers such as text in tables. This is extremely important for screen readers. A good source for accessibility considerations is W3C 5.3 Do not use tables for layout unless the table makes sense when linearized. Otherwise, if the table does not make sense, provide an alternative equivalent (which may be a linearized version).
>
> 5.4 If a table is used for layout, do not use any structural markup for the purpose of visual formatting. Source: https://www.w3.org/TR/WAI-WEBCONTENT/checkpoint-list.html
>
> You mention font style. Here is another source on fonts --

http://dyslexiahelp.umich.edu/sites/default/ les/good_fonts_for_dyslexia_study.pdf . This recommendation was also added on to the text design principles.

Adding video and audio. Four of the five expert reviewers strongly agreed or agreed that the considerations for adding video and audio were clear and easy to understand, and one expert reviewer took a neutral stance on this question. Reviewer One stated that they were not in agreement with the idea of avoiding onscreen text with narration and mentioned that "Having captions on the video can be very helpful on mobile, especially when viewing the video in a public space where it may not be possible to listen to the audio track. Take a look at the videos on the BBC News website - most of these now have captions as well as audio track." This suggestion was clarified in the considerations. Specifically, "narration" in the video/audio considerations meant explaining or telling a story, and was not originally in reference to onscreen captions. The researcher agrees that captioning is crucial as is stated in the considerations for audio content. Reviewer Two also indicated that, "Perhaps you could add a guideline about providing easy and accessible controls for video/audio playback (pause, back up, skip forward). The first guideline mentions animation and is a duplicate of the single animation guideline in the next section. I don't think there's a need to separate animation from video and would suggest combining them into one category." This recommendation was also incorporated into the considerations. Reviewer Four mentioned that, "The first sentence in this section primarily pertains to the use of animation. The second bullet in this section suggest using text to speech features in authoring tools - it is unclear why? I am very familiar with such tools but other than rapidly adding text such as creating captioning easier, I am not sure why you suggested this." The statement under question was removed from the considerations to further clarify the point.

Adding Animation. When asked if the considerations for adding animation were clear and easy to understand, two of the five reviewers agreed. Three of five of the experts took a neutral stance. Various suggestions were provided to improve the animation design principles. Reviewer One stated that they did not agree with the idea of not having onscreen text. Text can be particularly useful with animation, e.g. to label parts of an image. Based on a suggestion by Reviewer Two to add the animation design principle to the video and audio design, the principles were combined because of their similar characteristics. Reviewer Three also asked, "is 'narration with text' the same as CC? Why avoid that if we're recommending including transcripts and closed captioning?" This was previously suggested for the video and audio principles. As a result, this principle was clarified for easy understanding. Reviewer Five finally suggested:

> I would add a little more here. i.e. W3C guidelines suggests 1.3 Until user agents can automatically read aloud the text equivalent of a visual track, provide an auditory description of the important information of the visual track of a multimedia presentation. 1.4 For any time-based multimedia presentation (e.g., a movie or animation), synchronize equivalent alternatives (e.g., captions or auditory descriptions of the visual track) with the presentation.

Adding graphics. All five of the expert reviewers strongly agreed or agreed that the considerations for designing graphics were clear and easy to understand. Three of the five provided further suggestions to improve the considerations. Reviewer One reiterated that the key is "appropriate." The text and graphics must complement each other, which further solidifies this guideline. Reviewer Two also stated that, "Perhaps a guideline about the placement of graphics and related text? Use the Gestalt principles to design graphics/text that are easily grouped by the

human perceptual system." Finally, Reviewer Five suggested to add alt text descriptions to graphics.

Adding color. In this category, all five of the expert reviewers agreed or strongly agreed that the considerations for adding color were clear and easy to understand. Two of the five expert also offered further recommendation to improve it. Reviewer One suggested to consider adding how the colors are viewed in strong sunlight. Use a color contrast checker, e.g. https://webaim.org/resources/contrastchecker/. Reviewer Five also suggested to add to this section that 'do not rely on color alone' according to W3C guidelines 2.1. This recommendation was incorporated in the considerations.

Applicable indicators. The applicable indicators focused on generalization and interpretation, conducting usability analyses, and recognizing "real world" constraints on the use of the considerations. Table 9 highlights the indicators included in the study. Four of the five of the expert reviewers strongly agreed or agreed that the considerations are useful. However, Reviewer One disagreed. As far as viability was concerned, four of the five of them also strongly agreed or agreed that the considerations were viable while 1 of the five experts disagreed. Again, four of five strongly agreed or agreed that the considerations were relevant and 1 of the experts disagreed with the notion. Four of five of the experts found the considerations both easy to understand and reliable and one of five responded that that they disagreed. On average four of five of the reviewers believed that the considerations were useful, viable, relevant, easy to understand, reliable, and adequate for their purposes.

Table 6:

Summary of Indicators Applicable to Considerations

	Usefulness	**Viability**	**Relevant**	**Easy to understand**	**Reliable**	**Adequate**
Strongly Agree	1	2	1	1	2	1
Agree	3	2	3	3	2	2
Neutral	0	0	0	0	1	1
Disagree	1	1	1	1	0	1
Strongly Disagree	0	0	0	0	0	0

Practicality. Experts were asked to assess the overall practicality of the considerations. Specifically, they were asked whether the considerations were suitable for a particular purpose or situation. One expert indicated that it was excellent, three of the five experts responded that they were very good, and one indicated a fair response to this question. Reviewer Two explained that it would be helpful to designers and content developers if a link to examples were included in the considerations. This recommendation was previously suggested, and examples were added to the future considerations. These will eventually be housed on a separate website. Reviewer Five also suggested that the researcher develop new additional considerations, and provide more opportunities for the designer to learn more.

Effectiveness. The effectiveness of the considerations is the degree to which the considerations are successful in producing desired results. This was reviewed by four of the five experts as very good. One of the reviewers took a fair stance on the effectiveness. Further suggestions were provided by Reviewer One such as including examples of the considerations in use. Reviewer Two also suggested, "What if you created a mobile learning site for the

considerations themselves? This site could both present the considerations and be an example of the considerations applied. Just an idea; I don't think this is necessary, but it might be nice." This suggestion is a work in progress, and the considerations will be presented in this manner eventually. A website will be created for the considerations and further examples will be provided. Reviewer Five also mentioned that they thought the considerations could be very effective with careful revisions applied.

Real world constraints. Indicators were included in the survey questions for experts to decide whether real-world constraints could affect the use of the considerations. Table 10 displays the results.

Table7:

Summary Real World Constraints Result

	Time	**Budget**	**Available Data**	**Content to Develop**	**Level of Expertise**
Strongly Agree	2	0	0	1	2
Agree	1	2	0	3	3
Neutral	1	1	4	1	0
Disagree	1	1	1	0	0
Strongly disagree	0	1	0	0	0

From Table 10, it can be observed that four of five of the experts believed that a real-world constraint could likely affect the use of the considerations in the content to be developed. All five of the experts thought that level of expertise of the designers is also likely a real-world constraint, and three of five also strongly agreed or agreed that time could be a likely real-world constraint on the use of the considerations. As far as budget and available data were concerned,

the majority of the reviewers did not think that these would be real-world constraints in using the considerations as evidenced by four of five of them taking a neutral stance on available data, and another three of five of them indicating a neutral stance, disagreeing or strongly disagreeing. Reviewer Three mentioned that specific design requirements for the project might be in conflict with the principles, and that this could be a constraint. Reviewer Five also stated that there was a lack of testing/trialing versions that might ensure that the considerations would be accessible for all abilities.

Independent use. When asked if the considerations were comprehensive enough to stand alone, and whether they could be used without further message design guidance, two of five of the experts answered yes and three of five responded no. Some of the experts added that to make the considerations stand alone, opportunities to see examples and to learn more should be provided. One expert also suggested that the type of mobile phone (for example "smart phones") should be clarified in the considerations.

In conclusion, this chapter presented findings based on the feedback from five expert reviewers, and discussed how the feedback was incorporated into the revised considerations. Appendix K presents a summary of the revisions applied to the considerations, and Appendix L showcases the revised considerations for designing content for mobile phones.

Summary of Revisions Made to Considerations

Many of the Reviewers suggested adding examples alongside the considerations. Providing examples alongside the considerations will be added at a later date. The researcher intends to create a website for the considerations at which time detailed examples and resources will be added. Further, another suggestion from one of the reviewers was to allow for consistency throughout regarding sentence structure (e.g., start with a verb for example written).

The sentence structure was reordered throughout the considerations, beginning with a verb, for consistency.

Reviewer Two also suggested adding design as a context category. This suggestion was also incorporated in the considerations, a section named "design for context" was added as a category. These changes are evidenced in Appendix L. Another very common suggestion among the reviewers was to add, "keep the sentences short and concise" to the considerations. This principle was included in the general content design principles. Consideration for how colors are viewed in strong sunlight was a recommendation, and this was added to the color design principle. Some of the considerations were unclear and spelled incorrectly. These were addressed by rewording the particular guideline for clarity. Some of the considerations were also repeated in various places, and this was rectified.

The first two categories (General Design and Design for Function) were further broken down into the general content design, design for function, and general content presentation upon the suggestion of Reviewer Two to reclassify the first two categories into three sections (content design, content presentation, and functionality). Easy and accessible controls for video/audio playback were included in the video and audio design considerations based on Reviewer Two's recommendation. Animation design principles were combined with video and audio design principles as suggested by Reviewer Three. Reviewer Four asked if the fonts for the considerations were sans-serif. However, the study's APA requirement suggests Times New Roman.

Consistency of navigation was included in the general design principles considerations. Reviewer Five mentioned that, "You do not address some of the accessibility barriers such as text in tables as is extremely important for screen readers." A statement and resources will be

added to the website to refer users to other accessibility principles as this is outside the scope of the study. Additionally, "do not rely on color alone example, ensure that if that content is without color, it will convey the same meaning" was added to color design upon the suggestion of Reviewer Five. Adding alt text was included in the graphic design principles to allow for accessibility.

The word "narration" was clarified in the adding video and audio category to differentiate it from closed captioning. Finally, the proximity Gestalt Theory was included to clarify the principle further. "Elements that are close to each other are perceived as more related than elements that lie farther apart" to add clarity. See Appendix L for the details regarding the revised considerations, and Appendix K for the summary of reviewer recommendations and how they were incorporated.

Chapter Six

Conclusions and Recommendations

The purpose of this study was to develop a set of considerations for designing messages for mobile learning, primarily through literature review and expert reviewer feedback. The considerations were created from a learning and accessibility perspective. A study conducted for 1500 college-level online students by The Learning House and Aslanian Market Research (2017) showed that only 23% of online students would not want to use their mobile devices in accessing online classes. This means that 77% of students in the study used/desired to use their mobile devices to access online content. Therefore, there is a need to create online content specifically with the students in mind, and learning and accessibly of content for all students is fundamental. The final chapter summarizes the conclusions of the study and provides recommendations resulting from expert review feedback. This chapter highlights a review of the study, potential contributions (practical and theoretical) limitations of the study, recommendations for future application, next steps, and overall summary of the study.

Review of the Study

The last decade has seen a revolution in communications and computing technology with the installation of digital cellular phone networks, and the growth of mobile computers and digital cameras (Sharples, Corlett, & Westmancott, 2002). Mobile device use is on the rise in the world today, and these devices are becoming very popular in the education sector for both developed and developing countries (Traxler, 2007).

A careful and comprehensive study of existing literature confirm earlier studies (Gao, Novak & Tang, 2009; Haag & Berking, 2015; Saleh & Bhat, 2015; Shen, Vincent-Layton, 2015; Wang & Shen, 2012; Wang & Wishart, 2009) suggesting that there has been very little empirical

research conducted in the area of instructional message design in mLearning. As a result, this study aimed to conduct further empirical work on instructional message design for mLearning for the purpose of designing meaningful instructional materials for mobile phones.

This study employed design and development research methodology comprised of three phases which involved analysis, development and revision, and evaluation. The analysis phase involved a thorough search of literature in broad areas such as multimedia learning, universal design principles, and mobile interface design best practices. The search provided the foundation and data needed to develop the considerations. The next step was to develop the considerations. In the development stage, the findings from the literature search were used to develop a set of considerations for designing mobile content. Further, expert reviewers were asked to provide feedback on the considerations through an online survey. The final phase consisted of revising and evaluating the considerations based on expert reviewer feedback.

The study resulted in a set of considerations for designing instructional messages for mobile learning. These considerations generated from a learning and accessibility standpoint. From a learning perspective, the study used Clark and Mayer's (2016) multimedia principles and their application to designing for mobile learning. From an accessibility standpoint, the study utilized Center for Universal Design (1997) universal design of instruction (UDI) principles and how they are applicable to instructional message design in mobile learning. UDI principles were used for this study as they represent a broader range of students with regards to accessibility. For the purpose of this study, these research-based perspectives were incorporated to inform the used as it informed the parameters of the study. Mobile interface design best practices were also included in the development of these considerations.

Practical Contributions of the Study

This study contributes to research and content development in several ways. First, the use of mobile phones for accessing online content has become a common phenomenon in online learning (Statistica, 2017). However, there is lack of research done in this area as evidenced in a comprehensive study of existing literature (Gao, Novak & Tang, 2009; Haag & Berking, 2015; Saleh & Bhat, 2015; Shen, Vincent-Layton, 2015; Wang & Shen, 2012; Wang & Wishart, 2009). This shows that very little empirical study has been conducted in the area of instructional message design in mLearning. This study contributes to the limited instructional design literature on considerations for designing mobile content for the purpose of education. This resource will also support instructional designers and content developers of online learning. Given that a broader array of delivery options is now possible, it is even more important that evidence-based guidance is available to guide the design of mobile and blended learning courses and programs. These considerations offer such support, based on prior research (Beirne and Romanoski, 2018). Beirne and Romanoski (2018) further mentioned that, "growing numbers of students are looking for more flexible formats for undertaking courses, certificates and degree programs" (p. 1). This phenomena demonstrates the need to follow principles in designing content for online learning.

The considerations developed in this study compiled recommendations to address important principles of instructional message design and universal design, and integrated them into one comprehensive tool to support instructional design for mobile learning. In any effective instructional content design, effectively communicating an intended outcome to users/learners is critical for learning to take place. The considerations for this study were based on two of the most important considerations for designing instructional messages. The considerations were

designed from a learning and accessibility standpoint. The study ensures that empirically based considerations from both a learning and an accessibility stance were made available in one place for instructional content developers and instructional design practitioners. The study also supports the practical work of instructional designers and content developers of online learning. The implementation of the considerations could impact and support quality instructional messages for mobile learning.

Theoretical Contributions of the Study

Richey, Klein, and Nelson (2004) stated, "the notion of development research is often unclear, not only to the broader community of educational researchers, but to many instructional technology researchers as well" (p. 1100). This study serves as an example of how a design and development research approach can be used in practice. The study followed the rigorous procedure of conducting tool research and also addressed some of the validity issues that could affect the use of the tool as suggested by Richey and Klein (2007). Tool development research involves the certification of all processes leading to the production of an instructional or non-instructional tool (Richey & Klein, 2007).

Lastly, this study contributes to the body of research on design and development research methodology. Tool development research and its impact is critical in instructional design and development. This study produced considerations for designing content for mobile phones. This area is not very heavily researched, and any study done in this area of research is of relevance to the design of effective instruction and the literature associated with it.

Limitations of the Study

Even though the study involved diverse experts, who in turn provided valuable recommendations and perspectives on the considerations, the feedback indicated that it would

have been more advantageous if more experts with computer science or human computer interaction were recruited. This could have been useful since the study dealt directly with mobile content design. Richey and Klein's design and development research requirement for validity of tool research suggested that one should include varied perspectives from different experts in fields related to the study.

No field test was conducted for this study. Consequently, the usability and practicality of the considerations cannot be validated at this time. Different organizations also vary in many ways. Thus, the application of the tool would have to fit the specific environment in which it is going to be used. An organization may have specific rules or guiding principles that they may need to adhere to. These may be contrary to the recommendations provided in the considerations. The analysis phase of the study was primarily through literature review and depended heavily on the researcher's boundaries and discretion. Consequently, certain indicators may have been missed or left out in the literature search. Since design and development research is an iterative process, the considerations will continue to evolve (Richey & Klein, 2007), and will eventually be showcased on a separate website with examples, non-examples, and resources.

Recommendation for Future Application

A field test will be necessary to validate the use of the considerations (Richey & Klein, 2007). The field test should be conducted with sample instructional designers, human computer developers, and content developers using the considerations in their natural environment. Formative evaluation should be performed at every stage, and changes made to improve the considerations.

Creating a mobile learning site for the considerations is useful for easy access to all the resources. This site could both present the considerations and specify examples for how the

considerations can be applied. It will also incorporate examples, non-examples, and references. The researcher envisions that the considerations will eventually stand alone. However, other resources might be useful when designing the content.

As far as further research is concerned, a creation of educational apps for mobile content development should be explored. Further systematic research should be conducted on instructional message design for mobile devices. Areas of potential interest include the difference between using smart phones and tablets to view instructional content and the difference between viewing online content on a desktop compared to mobile phones.

Next Steps

The implementation and utilization of the considerations is the appropriate next step in the considerations design process. A field test of the considerations will be necessary, which will result in further evaluation, revision, and checks for validity. As design and developmental research can be an iterative process of implementation and evaluation, the next phase of this study would be to have the considerations tested in the field (Jonassen, Cernusca, & Ionaas, 2007). The expert reviewer feedback has further emphasized how essential this area of research is, and that little research has been done. As one of the experts suggested, "I think the design of mobile applications for instruction is an important topic and one that our field has not really spent much time pursuing." As such, additional research on creating mobile applications for educational purposes along with testing of the current considerations can enhance the field of instructional design and content development for mobile learning.

Summary

Mobile learning has become very popular in recent years, and is continuing to grow rapidly. Mobile learning has been around since the early 2000's with the introduction of tablet computers. An extensive amount of research work has been done on mobile learning, however there is a paucity of research performed for designing the mobile content. To ensure that online content is all-encompassing and accessible to all online students without any cognitive overload, there is the need to incorporate evidence-based considerations in the design and development stage for online content. This study sought to design and develop considerations for mobile content from a learning and accessibility standpoint.

Based on expert review and feedback, the considerations for mobile content development can be useful to content developers and the field of instructional design as a whole. However, it was stated that incorporating the feedback will further strengthen the considerations. The feedback from expert reviewers was incorporated into the revised considerations. Most feedback from expert reviewers were incorporated, however other suggestions such as making of educational app for designing instructional content for mobile learning were not directly related to the study but fits well for future study, as such they were not added to the considerations. Other useful web content accessibility guidelines suggestions were provided which will be added as further accessibility guidance on the considerations website A field test of the considerations may be necessary to test how effective they are in the field, and further evaluation and feedback may be needed to improve the considerations. As part of the requirement to validate tools/considerations, Richey and Klein (2007) suggested that researchers should have participants verify reports of tool use, and further select participants with varying levels of

expertise to test tools. Testing the tool and making continuous changes are important components of tool and development research.

The literature has shown that there has not been a lot of research done in the area of instructional message design for mobile learning. As a result, this study set out to bridge this gap and contribute to the field of instructional design.

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Appendix A

Mobile Interface Design Best Practices

Table 8:

Summary of Studies in Mobile Interface Design Best Practices

Best Practice (What)	Description/ example (What is)	Location in the literature (Where)
Consistency	"look and feel" Elements of mobile interfaces such as names, color schemes, and dialog appearances Input/output methodologies that are device independent Have consistency in functionality	Gong & Tarasewich (2004) Lal (2013) Shneiderman, & Plaisant, (2010). Hoober & Berkman (2012)
Reversal of actions	Mobile applications should rely on network connectivity as little as possible	Gong & Tarasewich (2004)
Reduce short-term memory load	Recognition of function choices instead of memorization of commands. Use of modalities such as sound to convey information where appropriate. Designers avoid interfaces where learners must remember information	Gong, & Tarasewich (2004) Shneiderman, & Plaisant (2010)
Design for multiple and dynamic contexts	Configure output to users' needs and preferences (e.g., text size, brightness	Gong & Tarasewich (2004)
Design for small devices	Provide word selection instead of requiring text input	Gong, & Tarasewich (2004)
Design for limited and split attention	Provide sound and tactile output options	Gong, & Tarasewich (2004)

Best Practice (What)	Description/ example (What is)	Location in the literature (Where)
Design for speed and recovery	Allow applications to be stopped, started, and resumed with little or no effort	Gong & Tarasewich (2004)
Allow for personalization/ user-driven	Application should be up and running quickly Provide users the ability to change settings to their needs or liking Give user complete control	Gong, & Tarasewich (2004) Lal (2013) Hoober & Berkman (2012)
Design for enjoyment	Applications should be visually pleasing and fun as well as usable	Gong & Tarasewich (2004)
Overcoming lack of space/ Utilizing screen space Interaction mechanisms.	The mobile computer's lack of screen space caused by their small size Focus on problems connected to the limitations regarding screen space on mobile equipment	Brewster (2002) Nilsson (2009)
	Focus on problems connected to the limitations regarding interaction mechanism on mobile equipment handling input Addresses problems connected to entering information more efficient and/or with less probability for entering incorrect Information	Nilsson (2009) Subramanya & Yi (2006)
Design at large.	Focus on problems connected to design principles for user interfaces on mobile equipment Guidelines Addresses design guidelines on different levels of generality	Nilsson (2009)
Intuitive and easy to use	The interface should be simple enough for anyone educated or not to use	Subramanya & Yi (2006)

Best Practice (What)	Description/ example (What is)	Location in the literature (Where)
Optimizing the menus and user navigation	Provide a sufficient number of menu options to successfully do the job without overwhelming visitors	Subramanya & Yi (2006)
Design for immersiveness	The availability of powerful graphics co-processors, digital signal processors, and 3D displays can facilitate 3D visual effect	Subramanya & Yi (2006)
Functionality	Focus on single clear functionality	Lal (2013)
Simplicity	Keep design simple and clear	Lal (2013)
Accessibility	Make easier to use and access by multiple devices	Lal (2013)
Feedback	Allow for instant feedback when user issues command	Lal (2013)
Forgiveness	Allow for error prevention and allow undo Limit user error by enabling on required commands	Lal (2013)
Respect user-entered data	Preserve user data in the event of an error	Hoober & Berkman (2012)
Ensure that Lives take precedence	Mobiles are contextual and are used alongside people's actual lives.	Hoober & Berkman (2012)
Realize that user tasks usually take precedence	When the user is in the middle of a task, do not interrupt	Hoober & Berkman (2012)
Respect information	Do not modify the fundamental truth for saving space	Hoober & Berkman (2012)
Cater for universal usability	Recognize the diverse users	Shneiderman & Plaisant (2010)

Best Practice (What)	Description/ example (What is)	Location in the literature (Where)
Offer informative feedback	For user action, provide system feedback	Shneiderman & Plaisant (2010)
Permit easy reversal of action	Actions must be made reversal	Shneiderman & Plaisant (2010)
Permit internal locus of control	Users must have some control over the use of the device	Shneiderman & Plaisant (2010)
Practical Content	Addressing practical needs is the first principle in our design. To fit the nature of lifelong learning, content should be practical so it is easy for users to engage with while still in the flow of their routine	Gu, Gu & Laffey (2012)
Design micro content items as small, self-contained and granular learning	Having learning content fit into the fragmented time slots	Gu, Gu & Laffey (2012)
Learning activity needs to Micro and simple	Granular, one action for one activity, such as listening, reading or pushing a button to input feedback	Gu, Gu & Laffey (2012)
Usability: consistent and simple	interface design, navigation, control, feedback, error control, consistency and user satisfaction	Gu, Gu & Laffey (2012)

Appendix B

Expert Review Recruitment Email

School of Education,
Virginia Tech
Blacksburg, VA 24060
USA
April 27, 2018

Dear_____ ,

Invitation to provide feedback on Guideline for designing content for mobile phones.

My name is Eunice Ofori and I am a doctoral student in the Instructional Design and Technology program at Virginia Tech. As a recognized expert in_____, I would like to invite you to evaluate considerations that I have designed and developed as part of my dissertation work under the supervision of my advisor, Dr. Barbara Lockee (Lockeebb@vt.edu). Your participation in this study is voluntary.

The purpose of this study is to develop a set of considerations in designing messages for mobile learning (mobile phones) primarily through literature review and expert reviewers' feedback. The study employed a tool design and development research design with the following three stages: analysis, development and revision, and Evaluation. In the analysis stage, I conducted a comprehensive literature review on mobile learning, instructional message design, mobile interface design and the instructional message design principles for designing for mobile learning and finally mobile interface design. The development stage involved designing the considerations based on relevant literature. The evaluation stage requires that the considerations be formatively evaluated by experts for recommendations and improvement. Additional study details are provided in the consent form on the guideline website. No signature is required, rather, you will have the opportunity to indicate your voluntary consent to participate as an expert reviewer on the first page of the online survey document.

Should you accept this invitation, you will be provided a google site which has all the information you will need such as an overview to the dissertation, informed content, the considerations and the survey. I estimate that your participation would take approximately 1 hour of your time over a two-week review period, beginning with receipt of the considerations website. You will also be given the option of being acknowledged by name for your contribution as an expert reviewer or having your identity kept confidential.

Your expertise will enable me improve the guideline even further prior to its dissemination as a practical guideline for designers of mobile learning. I hope that you are able to participate. If you have any questions, please do not hesitate to contact me.

Thank you, in advance, for your valuable time and expertise.

Sincerely,

Eunice Ofori
PhD Candidate, Instructional Design & Technology
Virginia Tech.

akuafori@vt.edu

Appendix C

Expert Reviewers Resources Email

Dear Dr._____ ,

I would like to thank you for your response and willingness to serve as an expert reviewer for my study. I organized the elements of the research into one place on a google site for easy access. The resources can be found by clicking **here.**

The google site was organized into three sections, homepage, informed consent and guideline elements.

- The **Home** page provides an overview of the dissertation to displays a background information to the study.
- Next is the **IRB Informed consent** which provides further details about the study and understanding of the research and its risks.
- Finally, the **Guideline Elements** include four subpages which are overview of the considerations, considerations resources, considerations and expert review survey. The **overview of guideline** outlines the framework used for the guideline, the **resources of guideline** showcases the resources used in creating the considerations, **the Considerations** which details the guideline itself and **Expert Review survey** includes all the questions included in the online survey.

Please take some time to read the institutional review board (IRB) informed consent as you will be required to provide a consent in the survey. Also prior to taking the survey, take a look at the considerations to serve as a reference while providing the feedback. Finally use the survey to record your feedback and recommendation for the considerations. I estimate that your participation would take approximately 1 hour of your time over a two-week review period (By May 2nd).

Please indicate in writing if you will want to be acknowledged by you by name for your contribution as an expert reviewer or have your identity kept confidential.

Thank you again for your invaluable time and looking forward to your recommendation. Should you have any questions at any stage of the process please contact me (akuafori@vt.edu) Or my Advisor Dr. Barbara Lockee (lockeebb@vt.edu)

Sincerely,

Eunice Ofori.
PhD Candidate, Instructional Design & Technology
School of Education, Virginia Tech. akuafori@vt.edu

Appendix D

Expert Review Survey Participation Reminder

Dear Dr. _____

I recently contacted you to request your participation as an expert reviewer for my dissertation research on Considerations for designing instructions for mobile phones (see below for original email).

If you have completed the expert review, I want to thank you for your time and participation. If you have not completed the expert review yet, I eagerly wait for your input. Here is the link to the website.

Please complete the review by May 7nd 2018. Let me know if you have any further questions. Thank you for your time.

Sincerely,

Eunice Ofori
PhD Candidate, Instructional Design & Technology
School of Education, Virginia Tech.

akuafori@vt.edu

Appendix E

Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants

in Research Projects Involving Human Participants

Title of Study: Considerations for Instructional Message Design in Mobile Learning: A Design and Development Research
Investigator Name: Eunice Ofori
E-Mail: akuafori@vt.edu
Research Advisor: Dr. Barbara Lockee
Email: lockeebb@vt.edu

1. Purpose of this Study

The purpose of this study is to develop a set of considerations in designing messages for mobile learning primarily through literature review and expert reviewers' feedback. A current guideline for designing lessons for mobile devices will be made easily available for designers and the principles to follow when designing lessons for mobile phones and will inform them of sound design considerations.

2. How the results will be used

The results of the study will be used for research purposes and may be published and/or presented at a conference.

3. Eligibility

You must be 18 years or older to participate in this research.

4. Procedure

A recruitment email will be sent to the potential expert reviewers. A follow-up letter explaining the review process with a link to the guideline website will also be sent via the email. The website includes the initial considerations for designing for mobile phones, informed consent and the expert review survey. Reviewers will have two weeks to complete the review and provide the needed feedback through the online survey using google forms.

5. Time commitment

The Survey/ feedback will take about 1 hour of your time to complete from beginning to end over a 2-week period.

6. Risks

The risks associated with participating in this study are considered to be minimal.

7. Benefits

There is no specific benefit of the study to you however, you are encouraged to participate since it will benefit the community as a whole. The results of the study will provide insights into ways that messages should be designed to impart distance learning through the use of mobile phones to a target audience that is gaining more access to powerful mobile devices. Instructional designers will benefit from this research as it provides answers to principles for designers' lessons for mLearning.

8. Extent of Anonymity and Confidentiality

Participation in this study is confidential and your name will only be known to the study investigators. Every effort will be made to ensure your identity in this study will be treated confidentially unless you indicate another preference in writing to the investigator.

9. Compensation

You will not receive any form of compensation for participating in this study.

10. Freedom to Withdraw

It is important for you to know that your participation in this study is entirely voluntary and that you are free to withdraw from this study at any time without penalty. Also, your refusal to participate will result in no penalty or loss of benefits to which you are otherwise entitled. If you choose to withdraw from the study, the survey will end and no data will be used. Please contact the researcher Eunice Ofori (akuafori@vt.edu) or Advisor Dr. Barbara (lockeebb@vt.edu)

11. Participants Responsibilities

- Complete the online survey and return it to the investigator.
- Submit the evaluation, electronically once complete.
- (Optional) Indicate in writing if you would like to be acknowledged by name in the reporting of this research as an expert reviewer (otherwise, your name will be held in confidence).

12. Participant's Consent

You will have the opportunity to give your consent in the online survey.

13. Questions or Concerns

If you have any questions or concerns about this study, you can contact the investigators (Eunice Ofori: akuafori@vt.edu or Faculty Advisor: Dr. Barbara Lockee: lockeebb@vt.edu)

If you have any questions or concerns about how this study is conducted or about your rights as a participant, or if you need to report a research-related injury or event, you can contact Virginia Tech Institutional Review Board Phone: 540-231-3732, email: irb@vt.edu

Appendix F

Grouping the Considerations Framework Resources

Table 9:

Grouping the Considerations Framework Resources

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
1. Multimedia Principle (Mayer 2002, 2009)	Presentation of content should be a combination of both words and images. (Mayer, 2005).	People who learned from words and graphics produced between 55 percent to 121 percent more correct solutions to transfer problems than people who learned from words alone. Clark & Mayer (2016) People developed a deeper understanding of how the human heart works from text with simple illustrations than from text alone. Butcher (2006) "Research literature supports the general prescription that effective learning materials should combine visual and verbal materials in targeting to-be-learned concepts." Butcher (2014, p. 175)	Add appropriate graphics to text content to help learners' get the most of the content developed. Present information in multiple formats.
2. Modality principle	Students learn better from a combination of animation and	Students performed better on a transfer test after receiving a narrated animation on lightning	Avoid creating animation with narration and onscreen text as this

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
(Mayer 2002, 2009)	narration than from animation and on-screen text. (Mayer, 2002) People learn more deeply from a multimedia message when the words are spoken rather than printed. (Mayer, 2009)	formation than after receiving the same animation with on-screen captions that contained the same words as the narration. Moreno & Mayer (1999)	could cause cognitive overload. Choose narration when possible and avoid narration with text at the same time.
3. Contiguity Principle Mayer 2002, 2009)	The effectiveness of multimedia instruction increases when words and pictures are presented near each other in time or space (Mayer & Anderson, 1992) Learners build connections between corresponding words and graphics (Mayer, 2009)	Ginz (2006) and Moreno and Mayer (1999) found that students performed better on a transfer test after viewing an animation about lightning in which printed words were placed next to the part of the lightning system they described than when printed words were placed at the bottom of the screen as a caption	Place printed words near corresponding images or other media to bring more meaning to content.
4. Redundancy principle (Mayer 2002, 2009)	• People learn better from concurrent graphics and audio than from concurrent graphics, audio, and on-screen text (Clark and Mayer (2016)	• Avoid e-learning courses that contain redundant on-screen text presented at the same time as on-screen graphics and narration (Clark & Mayer (2016) • Learning from a diagram or graph is hurt by the addition of textual information that redundantly	Avoid including on-screen text with a narrated graphic as that will be duplicating information.

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
	• Students learn better from animation and narration than from animation, narration, and on-screen text. (Mayer, 2002) • People may waste precious processing capacity by trying to reconcile the two verbal streams of information or may focus on the printed words rather than the relevant portions of the graphics. (Mayer, 2009)	explains with words what the diagram or graph already shows pictures (Chandler & Sweller, 1991) • Students performed better on a transfer test about lightning when they received a narrated animation about lightning formation rather than the same narrated animation with concurrent onscreen text inserted at the bottom of the screen. (Moreno & Mayer, 2002)	
5. Coherence principle Mayer (2002)	People learn more deeply from a multimedia message when extraneous material is excluded rather than included. Student learning is improved when unneeded words or sound are eliminated from a multimedia presentation. (Mayer 2002) Rather than fully embellished textual or narrative descriptions, stick to basic and concise descriptions of the content. Clark & Mayer (2016)	• Consistency of "look and feel" should be the same across multiple platforms. Elements of mobile interfaces such as names, color schemes, and dialog appearances should have consistency in functionality. (Gong & Tarasewich, 2004), (Lal, 2013), (Shneiderman, & Plaisant, 2010). • Students who learned from a narrated animation on lightning formation performed better on a transfer test if the lesson did not also contain short video clips depicting lightning strikes (Mayer, Heiser, & Lonn, 2001). • When pictures are used only to decorate the page or screen, they are not likely to improve learning.	Avoid adding extraneous material which is not included in instructional goal or not relevant to the understanding of the content

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
		(Clark & Mayer, 2016)	
6. Personalization principle (Mayer 2002, 2009)	Students learn better when words are presented in conversational style rather than formal style. (Mayer 2002) Use conversational rather than formal style. Use polite wording rather than direct wording and use human voice rather than machine voice. (Clark & Mayer 2016) The rationale for this technique is that conversational style can	• People learn better from a narrated animation on lightning formation when the speech is in conversational style rather than formal style (Moreno & Mayer, 2000b) • The personalization and embodiment principles are particularly important for the design of pedagogical agents–on-screen characters who help guide the learning processes during an instructional episode (Clark & Mayer, 2016) • People work harder to understand material when they feel they are in a conversation with a partner rather than simply receiving information	Use a conversational style of writing unless otherwise specified when creating content for students. Use the first or second person in your narration or text.

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
	prime a sense of social presence in the learner, which causes the learner to try harder to make sense of what the instructor is saying (Mayer 2009)	(Beck, McKeown, Sandora, Kucan, & Worthy, 1996)	
7. Segmentation Principle Mayer (2002)	People learn more deeply when a multimedia message is presented in learner-paced segments rather than as a continuous unit. (Mayer, 2009)	• Design content as small, self-contained units. (Gu, Gu & Laffey, 2012) • Learners who received segmented content presentation performed better on transfer tests than the learners who received a continuous presentation, even though identical material was presented in both conditions (Mayer & Chandler, 2001) • Mayer, Dow, and Mayer (2003)'s study about how an electric motor works found that students who watched a continuous narrated animation or by watched a segmented version did not perform as well as their counterparts who watched the segmented version.	Design mobile content in small or unit sections to enable learners better understand without any overload.
8. Pre-training Principle (Mayer 2002, 2009)	People learn more deeply from a multimedia message when they have first learned the names and characteristics of the main concepts (Mayer, 2009)	People performed better on problem-solving transfer tests when a multimedia lesson was preceded by pre-training in the names and characteristics of each key component. (Mayer, 2009)	Include names and characteristics of main concepts at the beginning of mobile content when designing a module to help leaners gain awareness of each major component.

Application of Multimedia Principles to Designing Content for Mobile Phones			
Multimedia Principle	**Principle's Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
		Across three experiments, they found consistent evidence for pre-training principle: Before presenting a multimedia explanation, make sure learners visually recognize each major component, can name each component, and can describe the major state changes of each component. (Mayer, Mathias, & Wetzell, 2002).	
9. Signaling Principle (Mayer 2002, 2009)	People will learn more efficiently if the lesson is designed to call their attention to the most important material in the lesson. (Mayer 2009) People learn better when cues that highlight the organization of the essential material are added (Mayer, 2009)	Signaling of the verbal material includes using an outline, headings, highlighting (such as underlining) and pointer words (such as first, second, third). Signaling of visual material includes arrows, flashing, and spotlighting. For example, in a narrated animation on how an airplane achieves lift, students performed better on a transfer test if the narration included an initial outline, headings, and voice emphasis on key words (Mautone & Mayer, 2001). Stull and Mayer (2007) reported in a study that concluded that, people learn better from a multimedia message when the text is signaled rather than non-signaled	Use text signaling strategies such as outline, headings, highlight, bolding, pointer words such as first, second etc. when designing mobile content to draw learners attention to salient points.

Application of Universal Design Principles to Designing Content for Mobile Phones			
UDI Principle	**Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
1. Equitable use.	The design is useful and marketable to people with diverse abilities. Develop content and assignments that can be accessed on a wide variety of devices. Course content should be accessible to people with diverse abilities and in diverse locations. (Elias, 2011)	• Cater for universal usability and recognize the diverse users. Shneiderman & Plaisant (2010) • Design for multiple and dynamic contexts, configure output to users' needs and preferences (e.g., text size, brightness. (Gong & Tarasewich, 2004) • A study at a South African high school, for example, indicated that only 33% of students had access to phones with substantial internal and flash-card memory. (In Elis, 2011)	• Deliver content in the simplest possible formats. Short Messaging Systems (SMS), or texting technology is cheap and given its high levels of penetration is universally accessible. (Elias, 2011) • Given the small storage capacity of most smart phones and do not have a big storage capacity using cloud-computing file storage and sharing sites may be a better option. Example most of Google's services could be considered cloud computing (Gmail, Google Calendar, Google Maps) (Elias, 2011)

Application of Universal Design Principles to Designing Content for Mobile Phones			
UDI Principle	**Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
2. Flexibility in Use	Accommodating a wide range of individual abilities, preferences, schedules, levels of connectivity, and choices in methods of use Elias (2011)	• Ensure that lives take precedence because mobiles are contextual and are used alongside people's actual lives. (Hoober & Berkman, 2012) • Make it easier to use and be accessed on multiple devices. (Lal, 2013) • Do not use pop-ups, mouse hover, or auto refresh. (Lal, 2013) • Should be Intuitive and easy to use. The interface should be simple enough for anyone educated or not to use. (Subramanya & Yi, 2006) • Allow for personalization and provide users with the ability to change settings to their needs (Gong, & Tarasewich, 2004)	• Design content such that mobile users who have smaller screens and bigger screens can still access the content they need. • Do not use pop-ups, mouse hover, or auto refresh for mobile contents as its more challenging if not impossible. Inputting text data into small devices can also present challenges for the user.
3. Simple and Intuitive use	Use design that is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. Center for Universal Design (1997) Unnecessary complexity should be eliminated and course design rendered simple and intuitive. (Elias, 2010, 2011)	• Keep design simple and clear, (Lal, 2013) • The interface should be simple enough for anyone to use. (Subramanya & Yi, 2006) • *Keep learners' interfaces simple*. It should be ensured that they contain only information that can fit comfortably on the smallest of screens. (Elias, 2011) • Use memorable short titles, professional icon, and precise description. (Lal, 2013) • Allow website to scale for all mobile browser layouts for both portrait and landscape. (Lal, 2013) • Use simple words for links and buttons. (Lal, 2013) • Focus on single clear functionality. (Lal,	• Design the content in very simple and easy to understand format. Think about designing for the smallest mobile phone content and ensure content will fit without cognitive overload. • Preview the content on a mobile phone before sending it out to students. If the tool you are using to design has responsive functionality, look over on the smallest mobile size to ensure the content is clearly displayed. • Speech input is a viable alternative since some devices may be too

Application of Universal Design Principles to Designing Content for Mobile Phones			
UDI Principle	**Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
		2013)	small for buttons.
4. Perceptible Information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities. (Center for Universal Design, 1997) Adding captions, descriptors, and transcriptions increases learners' perception of the content and reaches everybody in spite of any disability. (Elias, 2010)	A video presentation should include alternative forms of the spoken work, including captions, descriptors and transcriptions. (Burgstahler, 2009; Elias, 2010))	Add captions to video content and transcripts to audio content. You can use text to speech features in authoring tools.
5. Tolerance and Error	• The design minimizes hazards and the adverse consequences of accidental or unintended actions.	• Users must have some control over the use of the device. (Shneiderman & Plaisant, 2010)	• Design content such that learners can go back to review content which was previously viewed.

Application of Universal Design Principles to Designing Content for Mobile Phones			
UDI Principle	**Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
	(Burgstahler, 2012) • Minimize hazards and adverse consequences of errors in software operation by designing learning environments with a tolerance for error. (Elias, 2011) • This includes ability to edit after posting, confirming before sending assignments and warnings when leaving course site. (Elias, 2010)	• Allow for error prevention and allow undo action. • Allow website to scale for all mobile browser layouts for both portrait and landscape. (Lal, 2013) • Limit user error by enabling on required commands. (Lal, 2013) • Allow applications to be stopped, started, and resumed with little or no effort. (Gong, & Tarasewich, 2004) • Provide word selection instead of requiring text input Gong & Tarasewich (2004)	• Provide opportunity to reduce error by allowing mobile content to be stopped and started as well as revisited.
6. Low physical and technical effort	The design can be used efficiently, comfortably, and with a minimum of fatigue. (Burgstahler, 2007; Elias, 2010)	• Focus on problems connected to the limitations regarding interaction mechanism on mobile phones. (Nilsson, 2009) • In addition to radio buttons, combo and check boxes, include spinners, sliders, and menu for easy manipulation which is usually more efficient and easier to perform than typing. (Nilsson, 2009) • Design finger friendly interaction menu choices for a number of interaction mechanisms, like lists, menus, buttons, keyboards, tab folders etc. (Nilsson, 2009) • Provide information about level of progress to make learners more patience and anticipate how long it will take to complete a module. (Nilsson, 2009)	• Limit use of external links • Use short messaging systems (SMS), or texting technology which is easy to use and available to all learners whether you have an advanced or simple mobile phone. • Include menu or table of content to a module for easy navigation.

Application of Universal Design Principles to Designing Content for Mobile Phones			
UDI Principle	**Explanation**	**Supporting Literature**	**How to Operationalize in Designing for Mobile Phones**
7. Size and Space	Appropriate size and space are provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility. Burgstahler (2007)	• Design for small devices and provide word selection instead of requiring text input. (Gong, & Tarasewich, 2004) • To overcome lack of space or utilize screen space, focus on problems connected to the limitations regarding screen space on mobile equipment. (Nilsson, 2009) • Keep design simple and clear. (Lal, 2013) • Have easy-to-use, at-a-glance view of information for the home screen • Respect information, do not modify the fundamental truth for saving space. (Hoober & Berkman, 2012) • Design micro content items as small, self-contained and granular learning. (Gu, Gu & Laffey, 2012) • Keep screen layout with plenty of white space and do not clutter. Keep one idea in one screen, and don't overload data. (Lal, 2013)	• Limit to one idea per screen • Use the phone screen effectively as it is small compared with regular desktop computer. • Design content in small units

Appendix G

Initial Considerations

General design principles

- **Avoid adding extraneous material** which is not included in instructional goal or not relevant to the understanding of the content.
- **Design the content in very simple and easy to understand format**. Think about designing for the smallest mobile phone content and ensure content will fit without cognitive overload.
- **Preview the content on a mobile phone** before sending it out to students. If the tool you are using to design has responsive functionality, look over on the smallest mobile size to ensure the content is clearly displayed.
- **Speech input is a viable alternative for content presentation** since some devices may be too small for buttons.
- **Limit use of external links**
- **Use short messaging systems (SMS),** or texting technology which is easy to use and available to all learners whether theyhave an advanced or simple mobile phone.
- **Include menu or table of content** to a module for easy navigation.
- Limit to **one idea** per screen
- **Include names and characteristics of main concepts** at the beginning of mobile content to help leaners gain awareness of each major component , for example include glossary section at the beggining of the module or content.
- Be **consistent** in the use of design elements like color, font, graphics, etc.

Design for function

- Design content such that learners can go back to **review content which was previously viewed**.
- Provide opportunity to reduce error by **allowing mobile content to be stopped and started** as well as revisited.
- Design content such that mobile users who have **smaller screens and bigger screens can still access** the content they need.
- **Avoid pop-ups**, mouse hover, or auto refresh for mobile contents as its more challenging if not impossible. These functions can be challenging due to screen size.
- **Use cloud-computing file storage** and sharing due to storage size
- When typing texual data, **Inputting text data into small devices can also present challenges** for the user.
- **Speech recognition** may be another plausible means of entering information.
- Present information in **multiple formats**.
- Design content in **small units**
- Limit to **one idea** per screen
- Deliver content in the **simplest possible formats.**
- **Present information in multiple formats**, for example, use a combination of text, graphics and video instead of each component only

Adding Text

- Place **printed words near corresponding images** or other media to bring more meaning to content.
- **Avoid including on-screen text with a narrated graphic** as that will be duplicating information.
- **Use text signaling strategies** such as outline, headings, highlight, bolding, pointer words such as first, second etc when designing mobile content to draw learners attention to salient points
- **Use a conversational style of writing text** unless otherwise specified when creating content for students. Use the first or second person in your narration or text.
- **Avoid adding extraneous material** which is not included in instructional goal or not relevant to the understanding of the content
- **Fonts used should be sans sarif** as they are associated with increased readability.

Adding video and Audio

- **Avoid creating animation with narration and onscreen text** as this could cause cognitive overload. Choose narration when possible and avoid narration with text at the same time.
- **Add captions to video content and transcripts to audio content**. You can use text to speech features in authoring tools.
- **Use a conversational style for narration** unless otherwise specified when creating content for students. Use the first or second person in your narration or text.

Adding Animation

- **Avoid creating animation with narration** and onscreen text as this could cause cognitive overload. Choose narration when possible and avoid narration with text at the same time.

Adding Graphics

- **Add appropriate graphics to text** content to help learners' get the most of the content developed.
- **Place printed words near corresponding images** or other media to bring more meaning to content.
- **Avoid including on-screen text with a narrated graphic** as that will be duplicating information.

Adding Color

- **Suitable color choice.** Color choice must be suitable for the anticipated audience, for example for younger audeince use more primary colors and for adult learners use tertiary colors.
- **Optimize contrast between text and background** by using colors appropriately.
- **Cautious use of color for cueing**. Color can be used for visual cueing but use cautiously . Apply visual cueing cautiously to ensure that learners can read the content and maximize retention and transfer
- **Keep color coding consistantly** throughout the whole content development.
- **Use contrasting colors** to highlight, and draw attention to key concepts

Figure 1. Initial Considerations

Appendix H

Expert Review Survey

Expert Review Survey

The purpose of the guidelines is to provide guidance to content developers, designers and instructional design professionals on the principles to follow when designing lessons for mobile phones. The Guidelines utilized Clark and Mayer (2016) Multimedia Principles, Universal Design of Instructions (Burgstahler (2012); Center for Universal Design. (1997), and Mobile Interface Design Best Practices. Please use the following rubric to record your notes as you review the document. Then provide your review for the " Guidelines for designing content for mobile phones". The survey has been divided into 2 sections, the first sections focuses on specific category of the the guidelines for designing content for mobile phones and the second section focuses on the practicality, effectiveness, independent use and real world constraints in the use of the guideline. The questions were formulated based on Richey and Klein (2007) validity recommendations and the specific characteristics of the guidelines. Please provide as much feedback as you can and feel free to direct any questions to me (Eunice Ofori, Ph.D. Candidate, Instructional Design, and Technology; akuafori@vt.edu) anytime throughout the review process. Your input is valuable and very much appreciated. The tool has been added at the site so you can refer to it as needed. Thank you!

* Required

1. **I have read the Consent Form included in the guideline site and the conditions associated with this study. I have also had all of my questions answered. Consent is indicated with submission of the survey. I hereby acknowledge and give my voluntary consent** *

Mark only one oval.

- ( ) Yes
- ( ) No

This section focuses on the specific category of the guidelines for designing content for mobile phones.

2. **The guidelines for the general design principles are clear and easy to understand** *

Mark only one oval.

- ( ) Strongly Agree
- ( ) Agree
- ( ) Neutral
- ( ) Disagree
- ( ) Strongly Disagree

3. **Please provide additional suggestions to improve the general design principles guidelines?**

https://docs.google.com/forms/d/1izu9KEd0XFQqTih_wJnEqMIf2YDPbPnSKITmyJdrOxw/edit 1/6

4. **The guidelines for designing for function are clear and easy to understand** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

5. **Please provide additional suggestions to improve the design for function category of the guidelines?**

6. **The guidelines for adding text are clear and easy to understand** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

7. **Please provide additional suggestions to improve the guidelines for adding text category?**

8. **The guidelines for adding video and audio are clear and easy to understand** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

9. **Please provide additional suggestions to improve the guidelines for adding video and audio category?**

10. **The guidelines for adding animation are clear and easy to understand** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

11. **Please provide additional suggestions to improve the guidelines for adding animations category?**

12. **The guidelines for adding graphics are clear and easy to understand.** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

13. **Please provide additional suggestions to improve the guidelines for adding graphics category?**

14. **The guidelines for adding color are clear and easy to understand.** *
Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

15. **Please provide additional suggestions to improve the guidelines for adding color category?**

This section focuses on the practicality, effectiveness, independent use and real world constraints in designing content for mobile phones.

16. **On the scale of 1 - 5, please specify the extent to which you agree that the following indicators are applicable to the guidelines. 1= Strongly Disagree 5= Strongly Agree** *
Mark only one oval per row.

	1	2	3	4	5
Usefulness (quality of being of practical use)					
Functionality (capable of serving a purpose well)					
Viability (capable of being use in a practical and useful way)					
Rationality (quality of showing good sense or practical judgment)					
Realism/pragmatism (the attribute of accepting the facts of life					
Relevant (show you something about the system that you need to know)					
Easy to understand (even by people who are not experts)					
Reliable (you can trust the information)					
Accessible data (information is available)					
Adequate (Provides sufficient basis to access performance)					

17. **How would you assess the overall practicality (suitable for a particular purpose or situation) of the guidelines?** *
Mark only one oval per row.

	Poor	Fair	Satisfactory	Very Good	Excellent
Level of Practicality of the tool					

18. **19. Please provide additional suggestions to improve its practicality?**

19. **How would you assess the overall effectiveness (degree to which something is successful in producing a desired result) of guidelines?** *
Mark only one oval per row.

	Poor	Fair	Satisfactory	Very Good	Excellent
Level of effectivenes of the tool					

20. **22. Please provide additional suggestions to improve the effectiveness of the guideline?**

21. **To what extent do you agree that the following real world constraints can affect the use of the guideline?** *
Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Time					
Budget					
Available Data					
Content to be Developed					
Level of Expertise					

22. **Are the guidelines comprehensive enough to be used without additional message design guidance?** *
Mark only one oval.

- Yes
- No

23. **If no, Please indicate below what can be done to make the guideline independent?**

24. **The organization and format of the guidelines are well designed to support its purpose and use** *
Mark only one oval.

- Yes
- No

25. **If no, Please indicate below how to better organize the format of the guidelines?**

26. **What additional recommendations do you have to improve these guidelines for designing mobile content?**

Thank you for your feedback.

Powered by Google Forms

Figure 2. Expert Review Survey

Appendix I

IRB Approval

VIRGINIA TECH

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	April 17, 2018
TO:	Barbara B Lockee, Eunice Ofori
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE:	Design and Development of Guidelines for Message Design for Mobile Phones
IRB NUMBER:	**18-195**

Effective April 17, 2018, the Virginia Tech Institution Review Board (IRB) approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Exempt, under 45 CFR 46.110 category(ies) 2,4**
Protocol Approval Date:	**April 17, 2018**
Protocol Expiration Date:	**N/A**
Continuing Review Due Date*:	**N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

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Appendix J

Expert Review Feedback

Table 10:

Summary of Expert Review Feedback

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
1. The general design principles considerations are clear and easy to understand	Agree	Agree	Strongly agree	Neutral	Strongly Agree
2. Please provide additional suggestions to improve the general design principles considerations?	It would be good to show examples of good practice alongside the considerations. Perhaps you could consider more the contexts in which mobile content will be accessed - for example, outdoors in bright sunlight, on a rainy day, on a	2nd guideline: I'm not certain from the wording whether this is referring to simplicity of content or simplicity of format. 4th guideline: Speech *input* is not a content *presentation* method. Do you		It isn't clear to me where this first set of considerations came from... you mentioned something at the beginning of this survey that suggests they came from "best practices" for mobile design but that literature wasn't presented here. Also, this seems to be quite a range of recommendations that	You have an item " Be Consistent" I recommend that you add navigation to your list.

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
	noisy train, in a quiet museum or library. It's not possible to design for all mobile contexts, but it's important to consider the main ones (e.g. outdoors in sunlight).	mean that content can be presented with speech audio, or that learners can navigate the content or interact with the content via speech? If the latter, you may need to link to some examples of how to do this effectively, since most mobile content does not use speech input. 6th guideline: It would be nice to link to some examples of how to use SMS in mobile learning.		include interface design, instructional design, and technology... can they be clustered around those main areas? And are they really sufficient or are there many additional things we could add here that are more specific to designing for mobile devices? (See my note below for more on this.) You also haven't provided us with any information about how these considerations will be presented moving forward. If they will stand alone, then I think they would be strengthened by providing examples and, perhaps, even screen shots that explain your meaning further. Also, for ease of reading and clarity, I suggest they be written consistently	

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
				throughout in terms of sentence structure (start with a verb, for example).	
3. The considerations for designing for function are clear and easy to understand	Strongly Agree	Agree	Agree	Agree	Strongly Agree
4. Please provide additional suggestions to improve the design for function category of the considerations?	Design for context - e.g. accessing and responding to content while walking (make buttons easy to click use with one hand). some general HCI principles are even more important with mobile, e.g.: Provide a single click back to a home page. Offer an 'undo' facility.	The category title "design for function" implies to me that this section will contain considerations for the interactive functionality or features of the mobile learning site/app/tool (i.e., activity design and interaction design). But many of these considerations are about content presentation (i.e., information design). To me, the first 7 considerations in	You have multiple formats listed twice, once with more detail.	While I agree what is in this section and the rest that follow are "clear and easy to understand," I think the bigger question for me at this point is more along the lines of what they contribute to our understanding of how to design for mobile interfaces. How is any of this any different than the advice you would provide a designer for any other platform? I think the bigger contribution you can make to the literature is in the kinds of	Remove the item " One idea per screen" you already have that in the previous section and it is not needed again.

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
		this section t in the "design for function" category, but the rest do not. Perhaps you could reclassify the considerations in the first two categories (general, design for function) into three sections (content design, content presentation, and functionality)		considerations you provide in your first section, above. I suggest that you try to get at the very specific ways in which designing for mobile devices is different and be sure your considerations address those things IN ADDITION to the existing considerations we have from the work of the MM Learning and UDL folks. Stated differently, in my opinion what you have under "function," "text," and so on, below, is redundant to what already exists in the literature and doesn't add anything to the discussion about designing for mobile. I suggest you focus on further developing your first section, above.	

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
5. The considerations for adding text are clear and easy to understand	Agree	Strongly Agree	Agree	Agree	Strongly Agree
6. Please provide additional suggestions to improve the considerations for adding text category?	Keep sentences short. Try not to put more text than can be read on a single phone screen. Use large font size. Check text for readability (e.g. with the Microsoft Word readability check).	"Avoid adding extraneous material" is a repeat of a guideline from the general category. "Sans serif" is misspelled. You might consider adding a guideline about making text as concise and focused as possible. On the smallest mobile phones, very little text can appear on the screen at once, so it would be good to write the text so that a complete idea can be seen on the	Is your font sans-serif?	See comment in "function" category, above.	You do not address some of the accessibility barriers such as text in tables. This is extremely important for screen readers. A good source for accessibility considerations is W3C 5.3 Do not use tables for layout unless the table makes sense when linearized. Otherwise, if the table does not make sense, provide an alternative equivalent (which may be a linearized version). 5.4 If a table is used for layout, do not use

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
		screen without scrolling.			any structural markup for the purpose of visual formatting. Source : https://www.w3.org/TR/WAI-WEBCONTENT/checkpoint-list.html You mention font style . Here is another source on fonts -- http://dyslexiahelp.umich.edu/sites/default/151les/good_fonts_for_dyslexia_study.pdf
7. The considerations for adding video and audio are clear and easy to understand	Agree	Strongly Agree	Agree	Agree	Neutral
8. Please provide additional suggestions to improve the considerations for	I don't agree that one should avoid onscreen text with narration. Having captions on the	Perhaps you could add a guideline about providing easy and accessible controls for		See comment in "function" category, above.	The first sentence in this section primarily pertains to the use of animation. The second bullet in this

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
adding video and audio category?	video can be very helpful on mobile, especially when viewing the[1] video in a public space where it may not be possible to listen to the audio track. Take a look at the videos on the BBC News website - most of these now have captions as well as audio track	video/audio playback (pause, back up, skip forward). The first guideline mentions animation and is a duplicate of the single animation guideline in the next section. I don't think there's a need to separate animation from video and would suggest combining them into one category.			section suggest using text to speech features in authoring tools - it is unclear why? I am very familiar with such tools but other than rapidly adding text such as creating captioning easier, I am not sure why you suggested this.
9. The considerations for adding animation are clear and easy to understand	Neutral	Agree	Neutral	Agree	Neutral

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
10. Please provide additional suggestions to improve the considerations for adding animations category?	Again - I don't agree about not having onscreen text. See above. Text can be particularly useful with animation, e.g. to label parts of an image.	I suggest combining the animation category with the video/audio category.	Is "narration with text" the same as CC? Why avoid that if we're recommending including transcripts and closed captioning?	See comment in "function" category, above.	I would add a little more here. I.e. W3C guidelines suggests 1.3 Until user agents can automatically read aloud the text equivalent of a visual track, provide an auditory description of the important information of the visual track of a multimedia presentation. 1.4 For any time-based multimedia presentation (e.g., a movie or animation), synchronize equivalent alternatives (e.g., captions or auditory descriptions of the visual track) with the presentation.
11. The considerations for adding graphics	Agree	Strongly Agree	Agree	Agree	Strongly Agree

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
are clear and easy to understand.					
12. Please provide additional suggestions to improve the considerations for adding graphics category?	The key is 'appropriate'. The text and graphics must complement each other. Typo: learners' -> learners	Perhaps a guideline about the placement of graphics and related text? Use the Gestalt principles to design graphics/text that are easily grouped by the human perceptual system.		See comment in "function" category, above.	I suggest adding alt text descriptions
13. The considerations for adding color are clear and easy to understand.	Strongly Agree	Strongly Agree	Strongly Agree	Agree	Strongly Agree
14. Please provide additional suggestions to improve the considerations for adding color category?	Consider how the colors are viewed in strong sunlight. Use a color contrast checker, e.g. https://webaim.org/resources/contrastchecker/			See comment in "function" category, above.	I would add to this section " Do not rely on color alone - W3C Considerations 2.1

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
15. On the scale of 1 - 5, please specify the extent to which you agree that the following Indicators are applicable to the considerations. 1= Strongly Disagree 5= Strongly Agree	• Usefulness – (5)Strongly Agree • Viability – 4 Agree • Relevant – 4 Agree • Easy to understand – 4 Agree • Reliable – 4 Agree • Adequate – 5 Agree	• Usefulness – (4) Agree • Viability – 4 Agree • Relevant – 4 Agree • Easy to understand – 5 Strongly Agree • Reliable – 5 strongly Agree • Adequate – 4 Agree	• Usefulness – (4) Agree • Viability – (5) Strongly Agree • Relevant – (5) Strongly Agree • Easy to understand – 4 Agree • Reliable – Agree • Adequate – 4 Agree	• Usefulness – (2) disagree • Viability – 2 disagree • Relevant – 2 disagree • Easy to understand – 2 disagree • Reliable – 3 neutral • Adequate – 2 disagree	• Usefulness – (5) Strongly agree • Viability – 5 Strongly Agree • Relevant – 4 Agree • Easy to understand – 4 agree • Reliable – 5 Strongly Agree • Adequate – 3 Neutral
16. How would you assess the overall practicality (suitable for a particular purpose or situation) of the considerations?	Excellent	Very good	Very good	Fair	Very Good

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
17. Please provide additional suggestions to improve the practicality of the considerations		Linking to examples of both good and bad practices for several of the considerations would help developers apply them.		See earlier comments	I would suggest that you model your own considerations. Provide more opportunities for the designer to learn more.
18. How would you assess the overall effectiveness (degree to which something is successful in producing a desired result) of considerations?	Very good	Very Good	Very Good	fair	Very Good
19. Please provide additional suggestions to improve the effectiveness of the considerations.	Provide some examples of the considerations in use.	What if you created a mobile learning site for the considerations themselves? This site could both present the considerations and be an example of the considerations		See earlier comments	With careful revisions. I think these considerations could be very effective.

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
		applied. Just an idea; I don't think this is necessary, but it might be nice.			
20. To what extent do you agree that the following real-world constraints can affect the use of the considerations?	• Time – Strongly agree • Budget – neutral • Available Date – Neutral • Content to be developed – Agree • Level of expertise – Agree	• Time – neutral • Budget – Agree • Available Date – Neutral • Content to be developed – Agree • Level of expertise – Agree	• Time – Agree • Budget – disagree • Available Date – Disagree • Content to be developed – Strongly Agree • Level of expertise – Strongly Agree	• Time – disagree • Budget –agree • Available Date – neutral • Content to be developed – neutral • Level of expertise – Strongly Agree	• Time – Strongly disagree • Budget –Strongly Disagree • Available Date – neutral • Content to be developed – Agree • Level of expertise –Agree
21. What other real-world constraints can you envision related to the considerations.			Specific design requirements for the project might be in conflict with the principles.		Lack of testing/trialing versions to ensure that it can be access for all abilities.

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
22. Are the considerations comprehensive enough to be used without additional message design guidance?	No	Yes	Yes	no	no
23. If no, please indicate below what can be done to make the guideline independent?	Provide some indication as to what you mean by 'content for mobile phones'. Are you proposing this primarily for classroom use? Or other contexts? What kind of mobile phones (smartphones only?).			See my earlier comments.	This was a tough one -it truly depends on the individual. I would always provide an opportunity to learn more or see examples.

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
24. Overall, the considerations, when used by content developers, will likely be effective in helping to improve the quality of mobile learning in distance learning experiences	Agree	Agree	Strongly Agree	Disagree	Strongly Agree
25. The organization and format of the considerations are effectively designed to support its purpose and use.	Yes	Yes	Yes	No	No
26. If no, please indicate below how to better organize the format of the considerations?		I think the current format is OK but see my specific suggestions on refactoring and combining some of the categories. I		See my earlier comments.	You have a great start- with a little tweaking and closely embedding accessibility considerations and using conversational

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
		think you want the categories to be non-intersecting, and the titles of the categories should clearly indicate where I should look to learn about considerations on a certain topic.			language could make your considerations very useful. I would suggest you add or look closely at Instruction and the UDL considerations for learning http://udlconsideratio ns.cast.org/?utm_me dium=web&utm_ca mpagin=none&utm_ source=cast- home

Summary of Expert Review Feedback					
Question	**Reviewer One**	**Reviewer Two**	**Reviewer Three**	**Reviewer Four**	**Reviewer Five**
27. What additional recommendations do you have to improve these considerations for designing mobile content?				Sorry to have been fairly negative in my review... but I think the design of mobile applications for instruction is an important topic and one that our field has not really spent much time pursuing. Simply "reconstituting" what we already know from MM Learning and UDL does not get at the issue here... we need specific guidance on the differences of designing for mobile and what to do about it. Lots of examples of good mobile design (both within and outside of education) and technical ways to accomplish those things would be a tremendous contribution. Please don't hesitate to reach out if I can be of any additional help.	Take a close look at the built-in accessibility features that can be used by users and developers to build content. In addition, look at innovative technologies that are built into the phones such as AI and eye gaze.

Appendix K

Summary of Guideline Revisions

Table 11:

Summary of Guideline Revisions

Expert Reviewer Feedback	Reflection in Revised Considerations
1. It would be good to show examples of good practice alongside the considerations. Perhaps you could consider more the contexts in which mobile content will be accessed - for example, outdoors in bright sunlight, on a rainy day, on a noisy train, in a quiet museum or library. It's not possible to design for all mobile contexts, but it's important to consider the main ones (e.g. outdoors in sunlight).	▪ Some examples of good practices alongside the considerations will be included at the later date when a website will be created.
2. I suggest they be written consistently throughout in terms of sentence structure (start with a verb for example).	▪ The sentence structure was reordered by starting with a verb for consistency
3. Design for context - e.g. accessing and responding to content while walking (make buttons easy to click use with one hand). some general HCI principles are even more important with mobile, e.g.: Provide a single click back to a home page. Offer an 'undo' facility.	▪ Design for context category was created ▪ Provide a single click back to a home page was added to design for context. ▪ Offer an 'undo' facility was included in design for context.
4. Keep sentences short. Try not to put more text than can be read on a single phone screen. Use large font size. Check text for readability (e.g. with the Microsoft Word readability check).	▪ Keep sentences short was added to general content design ▪ Try not to put more text than can be read on single phone screen was included in the general content design category

Expert Reviewer Feedback	Reflection in Revised Considerations
	▪ Check for readability was added to design for function principles.
5. Consider how the colors are viewed in strong sunlight. Use a color contrast checker, e.g. https://webaim.org/resources/contrastchecker/	▪ Added to color design principle to use contrast checker
6. 4th guideline: Speech *input* is not a content *presentation* method. Do you mean that content can be presented with speech audio, or that learners can navigate the content or interact with the content via speech? If the latter, you may need to link to some examples of how to do this effectively, since most mobile content does not use speech input.	▪ Reworded principle to reflect speech navigation ▪ Example of speech recognition will be included at a later date.
7. 6th guideline: It would be nice to link to some examples of how to use SMS in mobile learning.	▪ Examples of how to use SMS in mobile learning will be added to the principle at a later date when the guideline website is created.
8. The category title "design for function" implies to me that this section will contain considerations for the interactive functionality or features of the mobile learning site/app/tool (i.e., activity design and interaction design). But many of these considerations are about content presentation (i.e., information design). To me, the, the first 7 considerations in this section fits in the "design for function" category, but the rest do not. Perhaps you could reclassify the considerations in the first two categories (general, design for function) into three sections (content design, content presentation, and functionality).	▪ The first two categories, 'General design and design for function' principles were changed to General content design, Design for function and General content presentation.

Expert Reviewer Feedback	Reflection in Revised Considerations
9. "Present information in multiple formats" appears twice. "Limit to one idea per screen" is a repeat of a guideline from the general category.	▪ Deleted duplicate present information in multiple formats and limit to one idea per screen.
10. "Avoid adding extraneous material" is a repeat of a guideline from the general category.	▪ The repeated statement was deleted from the text design principle.
11. You might consider adding a guideline about making text as concise and focused as possible. On the smallest mobile phones, very little text can appear on the screen at once, so it would be good to write the text so that a complete idea can be seen on the screen without scrolling.	▪ Make text as concise as possible was added to text design principle
12. "Sans-serif" is misspelled.	▪ Correction was made to the misspelled word.
13. Perhaps you could add a guideline about providing easy and accessible controls for video/audio playback (pause, back up, skip forward)	▪ Easy and accessible controls for video/audio playback was included in the video and audio design guideline
14. Perhaps a guideline about the placement of graphics and related text? Use the Gestalt principles to design graphics/text that are easily grouped by the human perceptual system.	▪ The proximity Gestalt theory was included in this principle to further clarify the principle. "Elements that are close to each other are perceived as more related than elements that lie farther apart"
15. Linking to examples of both good and bad practices for several of the considerations would help developers apply them.	▪ Extensive examples will be added at a later date when the guideline website is created.

Expert Reviewer Feedback	Reflection in Revised Considerations
16. What if you created a mobile learning site for the considerations themselves? This site could both present the considerations and be an example of the considerations applied. Just an idea; I don't think this is necessary, but it might be nice.	▪ A guideline website will be designed in the future development and will not be added at this time.
17. I think the current format is OK but see my specific suggestions on refactoring and combining some of the categories. I think you want the categories to be non-intersecting, and the titles of the categories should clearly indicate where I should look to learn about considerations on a certain topic.	▪ Animation design principles were combined with video and audio design principles.
18. You have multiple formats listed twice, once with more detail.	▪ Maintain the multiple format with example and delete the duplicate.
19. Is your font sans-serif?	▪ The guideline's fonts will be changed to sans-serif on the guideline website to be created at a later date. Times New Roman was maintained as required by dissertation guidelines for consistency.
20. Is "narration with text" the same as CC? Why avoid that if we're recommending including transcripts and closed captioning?	▪ Narration was clarified to differentiate it from closed captioning
21. You have an item " Be Consistent" I recommend that you add navigation to your list	▪ Be consistent with navigation was included in the general design principles considerations.
22. Remove the item " One idea per screen" you already have that in the previous section and it is not needed again.	▪ The repeated 'one idea per screen' was removed.

Expert Reviewer Feedback	Reflection in Revised Considerations
23. You do not address some of the accessibility barriers such as text in tables. This is extremely important for screen readers. A good source for accessibility considerations is W3C 5.3 Do not use tables for layout unless the table makes sense when linearized. Otherwise, if the table does not make sense, provide an alternative equivalent (which may be a linearized version). 5.4 If a table is used for layout, do not use any structural markup for the purpose of visual formatting. Source : https://www.w3.org/TR/WAI-WEBCONTENT/checkpoint-list.html You mention font style . Here is another source on fonts -- http://dyslexiahelp.umich.edu/sites/default/	▪ A statement was added to refer users to other accessibility principles.
24. I suggest adding alt text descriptions	▪ Adding alt text was added to graphic design principles to allow for accessibility.
25. Do not rely on color alone - W3C Guidelines 2.1	▪ Added to the color design principles the statement "do not rely on color alone example, ensure that if that content is without color, it would convey the same meaning" to color design principles
26. Add examples	▪ Adding examples was a common suggestion by most of the experts as such some examples was added to the considerations and an extensive examples will be added when the guideline website is completed.

Appendix L

Revised Considerations

General Content Design

- **Avoid adding extraneous material** which is not included in instructional goal or not relevant to the understanding of the content.
- **Design the content in very simple and easy to understand format**.
- **Preview the content on a mobile phone**.
- **Use speech input as a viable alternative for content presentation.**
- **Limit use of external links**
- **Use short messaging systems (SMS),** or texting technology which is easy to use and available to all learners inspite of the type of phone
- **Include menu or table of content** to a module for easy navigation.
- **Limit to one idea per screen**
- **Include names and characteristics of main concepts**
- **Apply consistentency** in the use of design elements like color, font, graphics, etc.
- **Keep sentences short** and concise
- **Be consistent with navigation**
- Try not to put **more text than can be read on single phone screen**

Design for context

- **Provide a single click back to a home page.**
- **Make buttons easy to click/use** with one hand.

Design for function

- Include ability to **go back to review content which was previously viewed**.
- Provide opportunity to reduce error by **allowing mobile content to be stopped and started** as well as revisited.
- Design content such that mobile users who have **smaller screens and bigger screens can still access** the content they need.
- **Avoid pop-ups**, mouse hover, or auto refresh for mobile contents as its more challenging if not impossible.
- **Use cloud-computing file storage** and sharing due to storage size
- When typing texual data, **Inputting text data into small devices can also present challenges** for the user.
- **Applingy Speech recognition** may be another plausible means of entering information.

General Content Presentation

- Design content in **small units**
- Deliver content in the **simplest possible formats.**
- **Present information in multiple formats**, for example, use a combination of text, graphics and video instead of each component only
- **Use large font size**
- **Check text for readability** (e.g. with the Microsoft Word readability check).

Adding Text

- Place **printed words near corresponding images** or other media to bring more meaning to content. Elements that are close to each other are perceived as more related than elements that lie farther apart
- **Avoid including on-screen text with a narrated graphic** as that will be duplicating information.
- **Use text signaling strategies** such as outline, headings, highlight, bolding, pointer words such as first, second etc when designing mobile content to draw learners attention to salient points
- **Use a conversational style of writing text** unless otherwise specified when creating content for students.
- **Use sans-serif fonts** as they are associated with increased readability.
- **Make text as concise as possible**

Adding video and Audio

- **Avoid creating animation with narration and onscreen text** as this could cause cognitive overload. Choose narration when possible and avoid narration with text at the same time.
- **Add captions to video content and transcripts to audio content**. You can use text to speech features in authoring tools.
- **Use the first or second person** in your narration or text.
- Provide easy and accessible controls for video/audio playback (pause, back up, skip forward)

Adding Graphics

- **Add appropriate graphics to text** content to help learners' get the most of the content developed.
- **Avoid including on-screen text with a narrated graphic** as that will be duplicating information.
- **Add alt text descriptions to graphics.**

Adding Color

- **Suitable color choice.** Color choice must be suitable for the anticipated audience, for example for younger audeince use more primary colors and for adult learners use tertiary colors.
- **Optimize contrast between text and background** by using colors appropriately.
- **Cautious use of color for cueing**. Color can be used for visual cueing but use cautiously . Apply visual cueing cautiously to ensure that learners can read the content and maximize retention and transfer
- **Keep color coding consistantly** throughout the whole content development.
- **Use contrasting colors** to highlight, and draw attention to key concepts
- **Do not rely on color alone** example, ensure that if content is without color, it would convey the same meaning" to color design principles
- . Use a **color contrast** checker, e.g. https://webaim.org/resources/contrastchecker/

Figure 3. Revised Considerations