Next Generation Mobile Learning: Leveraging Message Design Considerations for Learning and Accessibility

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Abstract

Access to mobile learning (mLearning) opportunities has become widespread and continues to proliferate as a means of educational continuity during the COVID-19 pandemic. Due to such proliferation, guidance is needed to inform the design of mobile learning content from both learning and accessibility perspectives. Though evidence-based recommendations for mobile learning message design do not currently exist, prior research in multimedia learning and instructional design-related areas may be used to support the planning and production of such educational programming. Design efforts for mLearning would also benefit from the incorporation of strategies to enhance the accessibility of mLearning for learners with differing needs. Taking evidence-based practices from instructional design and universal design for learning could inform the future development of mLearning toward more effective learning experiences for all learners. Employing a design and development methodology, this study focused on the creation of evidence-based guidelines for mLearning content design, informed by prior research on instructional message design combined with recognized universal design principles for media-based learning. The study resulted in a set of considerations to guide the message design of accessible and effective mLearning experiences. The resulting guidelines underwent validation by expert reviewers representing the areas of instructional design, message design, universal design, and mLearning. Their feedback informed the final version of the guidelines produced as the outcome of this study, research-based considerations which can be practically applied by those responsible for the creation of mLearning instruction.

Keywords: accessibility, instructional message design, mobile learning

Mobile devices, for the purpose of education, have become a popular way for students to learn and access information (NMC Horizon Report, 2017). Uther (2019) stated that "Mobile learning has become one of the more influential aspects in the field of educational technology given the ubiquity of modern mobile devices and proliferation of educational applications or 'apps' for mobile devices" (p. 1). Mobile screens have the ability to support classroom learning in various capacities and settings (Pegrum, 2019). Researchers see the potential of mobile learning because of its portability, cost effectiveness, and communication features (NMC Horizon Report, 2017). McQuiggan, McQuiggan, Sabourin, and Kosturko (2015) define 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).

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. Effective instructional message design is crucial for learning to take place. 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). An instructional message also, "provides a setting for new information that is conveyed by a message" (Gibbons, 2014, p. 215).

With the popularity of mobile devices for learning purposes, instructional designers must adhere to sound instructional design principles to generate meaningful and effective instructional material. A design that adheres to evidence-based design principles will place images, spoken language, and printed words in proper combinations to maximize instructional effectiveness (Wang & Shen, 2012). A careful and comprehensive study of existing literature confirms earlier studies which indicate that very little empirical exploration has been conducted related to design strategies for mLearning (Haag & Berking, 2015; Saleh & Bhat, 2015; Shen, Wang, Gao, Novak, & Tang, 2009; Vincent-Layton, 2015; Wang & Shen, 2012; Wishart, 2009). As a result, there is a need for more systematic research focusing on instructional message design for mLearning in order to design engaging and accessible instructional materials for mobile devices.

Literature Review

Mobile learning, in contrast to other forms of distance education, is unique. Tereshchenko, Zagorskaya, Polyanskaya and Bobritskaya (2020) stated that learning using mobile devices offers new opportunities for students and teachers. Along with the flexibility and affordability of mobile technologies, challenges related to mLearning design are also present. Wang and Shen (2012) note the constraints of designing instruction to work effectively across a wide variety of sizes and formats. As such, Vavoula and Karagiannidis (2005) proposed that care should be taken to design mLearning content effectively from a learning standpoint.

Research-based strategies for the design and development have been noted in the literature. Vincent-Layton (2015) states:

> 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 (pp. 149–150).

Other researchers have noted the need for evidence-based guidance related to mLearning design. For example, 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). Additionally, 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). With prolific adoption of mLearning around the world, especially in response to the COVID-19 pandemic, practical research to inform mLearning design is essential.

Mobile Devices and User Interface Design

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). "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 design features of the user interface on a mobile device are an important aspect of the device to ensure efficient and effective usability. Punchoojit and Hongwarittorrn (2017) further 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).

Mobile devices also lack some affordances of standard computing technologies. For example, computers present a landscape view which, while possible on a mobile device, is not the typical approach to its use. To ensure that learners who are using these devices get the most out of it, care must be taken to consider the design constraints, as well as the many possibilities. 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).

Multimedia Theory for mLearning Design

The psychological principles from multimedia learning theory, long applied in the design of computer-based instruction, hold the potential to inform mLearning message design. Multimedia learning theory is grounded in the fact that instructional messages should be take into consideration how the human mind works (Mayer, 2001, 2005, 2009). Mayer (2009) describes multimedia learning as the presentation of instructional materials in words and pictures to ensure that learning takes place. Mayer (2009) 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. He 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). (Mayer, 2013, p. 395)

More recently, Clark and Mayer (2016) derived eLearning design principles from the earlier multimedia-related research of Mayer (2001, 2009). According to these authors, there are eight principles that instructional designers can follow to design instructionally sound eLearning materials. These principles include: multimedia, modality, contiguity, redundancy, coherence, personalization, segmentation, and pre-training principle (Clark & Mayer, 2016). Additionally, these scholars provided theory-based, concrete guidance for operationalizing these principles in e-learning environments, serving as a possible foundation for mLearning instructional development.

Universal Design of Instruction for mLearning

When considering plans for mobile learning design, it is important to also look at design strategies 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 to address a wide array of individual learner differences. UDI has been an important consideration for electronically delivered educational experiences since the early days of e-learning. In 1997, The Center for Universal Design at North Carolina State University developed a set of universal design principles that continue to inform accessible design strategies across disciplines and environments. These principles include: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance and error, low physical effort, and size and space considerations. Since then, interest in universal design for learning has continued to grow, reflecting many of these early principles. The current global pandemic has accelerated the define strategies for making mobile learning more accessible to all (Taildong & Toquero, 2021).

Need for the Study

Research conducted so far shows that mLearning is a growing trend as a learning delivery modality and the momentum it has taken will keep accelerating. Hanbridge, Tin, and Sanderson (2018) state that, "it is anticipated that mLearning will grow quickly in the next few years" (p. 119). As such, McQuiggan et al. claim that "the future adoption of mobile learning and the success of such efforts requires continuous awareness and integration of new technologies and functions" (2015, p. 333). The proliferation of mLearning underscores the imperative to develop evidence-based guidance for the design and development of effective mobile learning experiences, especially in the wake of the COVID-19 pandemic (Pebriantika, Wibawa, & Paristiowati, 2021).

Purpose of the Study

The purpose of this study was to propose a set of instructional message design guidelines for mobile learning content development, based on prior research in the areas of instructional message design and universal design for learning. A design and development research methodology was used to coalesce findings from the literature into a set of evidence-based mLearning design considerations. The resulting considerations are proposed for use by content developers and instructional design professionals in the overall instructional design process for mobile learning experiences.

Research Questions

The following research questions were used to guide this study:

(1) What evidence from prior research in the areas of instructional message design and

universal design be used to inform mLearning content design?
(2) How can such evidence be translated in a set of message design guidelines for the development of mLearning content?

Methodology

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 addresses two different types of inquiry: product and tool research (Type 1) and model research (Type 2). The proposed study employed product and tool research. This approach includes all of the processes leading to the production of an instructional or non-instructional tool (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 that experts with differing areas of specialization should be used for tool review.

Instrumentation

The survey for the expert reviewers consisted of three sections and 27 questions representing the specific guideline categories and validity factors. Section One focused on the general overview of the considerations and included a yes/no question to provide consent. Section Two of the survey focused on obtaining data about specific factors associated with the considerations. These factors included general design, functionality, text, color, video and audio, and graphics. Section Three emphasized the elements of design and development research recommendations. Sections of the survey inquired about the clarity of individual guideline categories and asked for any suggestions to improve them.

Study Procedures

The study employed three phases in its overall design. The first phase (Analysis) was to identify relevant design principles to guide mLearning creation. 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) involved taking the findings from the research and formulating a set of principles. This was achieved through synthesizing Clark and Mayer's (2016) multimedia principles, universal design principles, and mobile user interface design best practices. In the third and final stage (Evaluation and Revision), feedback and recommendations were gathered from five expert reviewers and revisions were made to the considerations based on their feedback. Institutional Review Board (IRB) approval was obtained before formal emails were sent to recruit potential reviewers.

Phase 1: Analysis. The guideline development process began with a comprehensive literature review of relevant topics pertaining to the research. The importance of doing a literature review is essential as it uncovers the knowledge gap and informs the study (Webster & Watson, 2002). The essential literature review areas covered for the study included instructional message design, principles for designing for mobile learning (mLearning), universal design principles, and mobile interface design.

Literature that was gathered for the study was carefully analyzed to determine relevance to the guideline development process. The articles, books, and other resources were critically

evaluated for any recurring ideas. Key areas included Clark and Mayer's multimedia principles (2016) and their interpretations, universal design principles for mediated instruction, empirical studies supporting each principle, applicable mobile interface design best practices, and any other content areas needed for the considerations.

Phase 2: Development. After analyzing the relevant literature, key research findings and best practices from the articles and resources were grouped as they aligned with multimedia and/or universal design principles. The purpose of engaging in this activity was to organize ideas to ensure that resources for each classification were easily accessible once the guideline building process began, as well as to ensure that each area was supported with credible evidence.

After careful analysis, four main categories were identified. These included statements of the principle, explanations of the principle, supporting literature, and how to operationalize considerations for designing instruction for mobile phones. These four categories organized the resources for easy understanding and interpretation. 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. Appendix A reflects Mayer's Multimedia Principles (2016) and the correlating recommendations operationalizing these principles based on relevant literature. Appendix B represents the outcomes of the literature analysis related to the Center for Universal Design's principles for universal design for instruction (1997). These foundational principles set the initial standards for the creation of accessible design, based on input from experts across a broad array of design sciences. Since their inception, these recommendations remain widely used to inform accessible web design (Zheng, 2021).

Following the identification of key design considerations from instructional message design and universal design literature, further synthesis was conducted to consolidate and organize these factors into overarching mLearning design recommendations. These guidelines were organized for application, with ease of use and functionality as key design priorities. Upon careful consideration, the following categories were chosen to frame the synthesized recommendations: general design principles for content and presentation, designing for context and function, and guidance for adding text, video and audio, animation, graphics, and color. The general design principles and specific suggestions for designing for function were stated first so that designers can easily access them for specific forms of content. Table 1 represents the culminating guidelines for mLearning message design.

Table 1
Guidelines for mLearning Message Design

General Content Design	• Design instructional text using a simple and clear writing style. • Limit concepts to one per screen. • Use speech input as a viable alternative for text entry. • Limit the use of external links. • Include a menu or table of contents for easy navigation of instruction. • Apply consistency in the use of design elements like color, font, graphics, etc. • Keep sentences short. • Be consistent with navigation functions. • Avoid the need for excessive scrolling. • Preview the content on a variety of mobile phone screens.
General Content Presentation	• Design content in small units. • Deliver content in the simplest possible formats. • Present information in multiple formats, such as a combination of text, graphics, and/or video. • Avoid small font size to ensure legibility. • Check text for readability
Design for Context	• Provide a clear and consistent way to return to the home screen. • Make buttons easy to click/use with one hand. • Navigation should provide easy access to help, both technical and instructional.
Design for Function	• Include the ability to review previously viewed content. • Provide the opportunity to stop and start module activities as desired. • Design content such that mobile users can readily view content, despite device screen size. • Avoid pop-ups, mouse-overs, or auto-refresh for mobile content. • Use cloud-computing file storage and sharing to address storage and access needs. • Explore the use of speech recognition as a plausible means of entering information.
Adding Text	• Avoid the inclusion of text that duplicates audio narration information. • Use text signaling strategies such as outlines, headings, highlighting, bolding, or pointer words (e.g., first, second, etc.) to draw attention to salient points. • Use sans-serif fonts to increase legibility. • Make textual content as concise as possible.

Adding Video and Audio	• Segment video and audio files into smaller chunks, when possible. • Add captions to video content and transcripts to audio content. Text-to-speech features can assist with this process. • Provide easy and accessible controls for video/audio playback (pause, go back, go forward).
Adding Graphics	• Add appropriate graphics to textual content to help visualize concepts. • Add alt-text descriptions to graphics.
Adding Color	• Use contrasting colors to increase legibility of text. • Use color for visual cueing. • Keep color coding consistent throughout the content design. • Use contrasting colors to highlight and draw attention to key concepts. • Use a color contrast checker to preview color selection decisions.

Phase 3: Evaluation and revision. Five expert reviewers were recruited from the areas of instructional message design, instructional design, mobile learning, and accessibility/universal design based on their expertise and scholarly reputation in these areas. These reviewers provided an evaluation of the proposed guidelines based, using a customized rubric created by the researchers to record their suggestions and feedback. Perspectives and recommendations from the reviewers were synthesized and revisions were made to the guidelines based on their collective input. Revisions that fell outside of the scope of the study were not addressed, such as a suggestion to create an app for guideline application.

Results

Overall, the expert reviewer feedback indicated that the guidelines would be helpful to instructional designers and content developers. Four out of five reviewers agreed that the proposed design strategies are likely to effectively improve the quality of mobile learning in distance learning experiences. Three of the experts also agreed that the organization of the considerations, a key design feature based on the synthesized literature, supported the purpose and use of the final product. Additionally, each of the reviewers provided feedback about the practicality and effectiveness of the proposed design guidelines, and indicated possible challenges related to their use. Some concerns were expressed about factors such as lack of designer expertise or project time constraints posing barriers for guideline usage for mLearning development. Each reviewer also provided feedback for revision of the considerations, with most recommendations focused on the technical writing style, nomenclature related to message design terms, and structuring of the recommendations to match the applicable design task. Much of the feedback provided was incorporated into the final version of the guidelines in Table 1, with some recommendations falling beyond the scope of the proposed study.

Discussion

The design and development activities in this study, framed by the following research questions, culminated in the final set of message design considerations for mLearning content:

(1) What evidence from prior research in the areas of instructional message design and universal design can be used to inform mLearning content design?
(2) How can such evidence be translated in a set of message design guidelines for the development of mLearning content?

Decades of inquiry and theory-based principles in the areas of multimedia learning, instructional message design, and universal design provided relevant insights to inform the aesthetic and functional design of mLearning content. Analysis and synthesis of these findings generated a practical collection of message design considerations for instructional content developers charged with mLearning creation that is accessible and effective.

A field test will be necessary to further validate the use of the proposed considerations (Richey & Klein, 2007). Such testing should be conducted with instructional designers, user experience design professionals, and potential faculty users, with the opportunity to apply the considerations in their natural environment. Formative evaluation should be performed at every stage, and changes made to enhance the usability and effectiveness of the considerations. Further systematic research should be conducted on the impact of instructional message design decisions, such as those proposed herein, on both student and instructor mLearning experiences.

Conclusion

The use of mobile phones for accessing online content has become a common phenomenon in online learning (Statistica, 2017) and has experienced exponential growth during the COVID-19 pandemic as a means of instructional continuity (Pebriantika, Wibawa, & Paristiowati, 2021). However, a long-standing need for research has existed to inform the design of mLearning content, given its unique aesthetic features and functional affordances (Gao, Novak, & Tang, 2009; Haag & Berking, 2015; Saleh & Bhat, 2015; Shen & Vincent-Layton, 2015; Wang & Shen, 2012; Wang & Wishart, 2009). This study offers guidance for designing mobile learning experiences, drawn from prior relevant research and best practices in multimedia learning, instructional message design, and universal design for learning. As Beirne and Romanoski (2018) state, “growing numbers of students are looking for more flexible formats for undertaking courses, certificates, and degree programs” (p. 1). Given that mLearning adoption and growth will likely continue into the future, it is even more important that evidence-based guidance, such as the message design considerations provided herein, is available to inform the design of mobile learning courses and programs.

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Appendix A

Mobile Learning Design Considerations by Multimedia Principle

Principle	Principle Explanation	How to Operationalize for mLearning Design	Supporting Literature
Multimedia Principle (Mayer 2001, 2009)	Presentation of content should be a combination of both words and images. (Mayer, 2005).	Add appropriate graphics to text content to help learners' get the most of meaning from the content. Present information in multiple formats.	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).
Modality principle (Mayer 2002, 2009)	Students learn better from a combination of animation and narration than from animation and on-screen text. (Mayer, 2002)	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.	Students performed better on a transfer test after receiving a narrated animation on lightning formation than after receiving the same animation with on-screen captions that contained the same words as the narration (Moreno & Mayer, 1999).
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	Place printed words near corresponding images or other media to bring more meaning to content.	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

	& Anderson, 1992). Learners build connections between corresponding words and graphics (Mayer, 2009).		of the lightning system they described than when printed words were placed at the bottom of the screen as a caption.
Redundancy principle (Mayer 2002, 2009)	People learn better from concurrent graphics and audio than from concurrent graphics, audio, and on-screen text (Clark & Mayer, 2016). Students learn better from animation and narration than from animation, narration, and on-screen text (Mayer, 2002).	Avoid including on-screen text with a narrated graphic as that will be duplicating information.	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 explains with words what the diagram or graph already shows pictures (Chandler & Sweller, 1991).
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 extensive narrative	Avoid adding extraneous material which is not included in instructional goal or not relevant to the understanding of the content.	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). When pictures are used only to decorate the page or screen, they are not likely to improve learning (Clark & Mayer,

	descriptions, stick to concise presentation of the content (Clark & Mayer, 2016).		2016).
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).	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.	People learn better from a narrated animation on lightning formation when the speech is in conversational style rather than formal style (Moreno & Mayer, 2000b). People work harder to understand material when they feel they are in a conversation with a partner rather than simply receiving information (Beck, McKeown, Sandora, Kucan, & Worthy, 1996).
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 mobile content in small or unit sections to enable learners better understand without any overload.	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).
Pre-training Principle (Mayer 2002,	People learn more deeply from a multimedia	Include names and characteristics of main concepts at the	People performed better on problem-solving transfer tests

2009)	message when they have first learned the names and characteristics of the main concepts (Mayer, 2009).	beginning of mobile content when designing a module to help leaners gain awareness of each major component.	when a multimedia lesson was preceded by pre-training in the names and characteristics of each key component (Mayer, 2009).
Signaling Principle (Mayer 2002, 2009)	People will learn more efficiently if the lesson is designed to call attention to the most important material (Mayer, 2009). People learn better when cues are added to highlight the organization of essential material (Mayer, 2009).	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.	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).

Appendix B

Mobile Learning Design Considerations by UDI Principle

UDI Principle	Explanation	How to Operationalize for mLearning design	Supporting Literature
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).	Deliver content in the simplest possible formats. Short Messaging Systems (SMS), or texting technology is inexpensive 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.	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).
Flexibility in use	Accommodating a wide range of individual abilities, preferences, schedules, levels of connectivity, and choices in methods of use (Elias, 2011).	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. Inputting text data into small devices can also present challenges for the user.	Ensure that lives take precedence because mobiles are contextual and are used alongside people's actual lives (Hoober & Berkman, 2012). 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).

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, 2011).	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. Speech input is a viable alternative since some devices may be too small for buttons.	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). Allow website to scale for all mobile browser layouts for both portrait and landscape (Lal, 2013).
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, 2011).	Add captions to video content and transcripts to audio content. Use text to speech features in authoring tools.	A video presentation should include alternative forms of the spoken work, including captions, descriptors and transcriptions (Burgstahler, 2009; Elias, 2011).
Tolerance and error	The design minimizes hazards and the adverse consequences of accidental or unintended actions (Burgstahler, 2012). Minimize hazards and adverse consequences of errors in software operation by designing learning environments	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.	Users must have some control over the use of the device (Shneiderman & Plaisant, 2010). Allow website to scale for all mobile browser layouts for both portrait and landscape (Lal, 2013).

	with a tolerance for error (Elias, 2011).		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).
Low physical and technical effort	The design can be used efficiently, comfortably, and with a minimum of fatigue (Burgstahler, 2007; Elias, 2011).	Limit use of external links Use short messaging systems (SMS), or texting technology which is easy to use and widely available. Include menu or table of content to a module for easy navigation.	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). Provide information about level of progress to make learners more patience and anticipate how long it will take to complete a module (Nilsson, 2009).
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).	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.	Design for small devices and provide word selection instead of requiring text input (Gong & Tarasewich, 2004). 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).