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Investigating the learning attitude of undergraduate students by analyzing the effectiveness of user interfaces for M-learning

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Abstract*: While Mobile learning referred to as M-learning has risen to be prominent in higher education and has led to potential growth in research concern, there seems to be inadequate empirical evidence from extensive experimental research to support its learning effectiveness. This article addressed this issue by conducting a randomized experiment on undergraduate students. This study investigates the effectiveness of different user interfaces of mobile devices on the M-learning attitude and perception of students enrolled in a graphic design course at the University. Students participated in three successive study sessions. A session including a presentation of the concept of M-learning and an overview of related mobile applications with their underlying course of graphic technologies was conducted outlining the scope and functionality for M-learning in the context of education of computer graphics, 2D and 3D Design at the university level. It was assumed that M-learning with iPad could lead to identical learning attitudes and perceptions among students as that by using an Android tablet, but students were found to have an enhanced learning attitude towards M-learning with iPad as compared to a tablet. M-learning can lead to the design and evolution of mobile-based educational curricula. This article aimed to provide several recommendations regarding improving the usability of the applications and enhancing readers' knowledge to enable future researchers to identify the emerging practices of mobile learning.*

Keywords— Mobile learning, usability, effectiveness, device compatibility, user interface.

1. INTRODUCTION

M-learning researchers attempt to maximize the utility of mobile technologies in higher education institutions while maintaining the educational mission. In the existing literature, researchers have defined M-learning from different perspectives. Mcconatha, Praul, and Lynch (2008) have defined M-learning as the learning that is employed using small computing mobile devices. This definition comprises smartphones and small handheld devices. Moreover, Mirski and Abfalter (2004) described M-learning as a specific topic that is emerging from distance learning; whereas Alzaza and Yaakub (2011) stated that M-learning is the next generation of E-learning that uses mobile technology. More elaborately, Homan, and Wood (2003) specified M-learning as the technology that changed the way the students communicate, interact, and behave with each other and their perceptions towards their learning. In addition, Al Emran and Shaalan (2014) demonstrate that M-learning facilitates knowledge sharing among students and educators while interacting with each other. Matias and Wolf (2013) expressed that M-learning is not only the learning that is based on the use of mobile devices but also the learning that is mediated across multiple contexts using portable mobile devices.

Briefly, M-learning helps students and educators to perform their daily tasks in a short period using small technological devices (tablets or smartphones) anytime anywhere. A need for an extensive user requirement analysis was analyzed for carrying out to define the functionality scope of the M-learning applications used with the capability to enhance the learning perception within the Bachelor of Arts cohort in the 'Studio Art' course at the Department of Mass Communications, Visual and Performing Arts, Delaware State University in the state of Delaware. The study involves 16 students attending the course at undergraduate studies. All participants performed their assigned task using their own mobile devices which run on iPad or Tablet.

M-learning facilitates learning flexibility in different categories of activities, including behaviorist, constructivist, situated, collaborative, personalized, and informal learning (Parson et al., 2007; Glavinic et al., 2008). However, with the affordability of telecommunication services and the vast availability of a wide range of user interfaces for end-user devices, M-learning content. M-learning has undisputedly gained momentum in becoming the potential mainstream of the current generation. Legris, Ingham, and Collerette (2003) stated that Technology Acceptance Model (TAM) has been designed due to the reason to determine how end-users could accept or reject a specific technology. Further, Ardies, De Maeyer, Gijbels, and van Keulen (2014) argued that attitudes towards any educational technology could be used to measure which usability analysis of mobile interfaces for M-learning is becoming extensively significant in handling high-end extent the users of the technology (students and educators) have the ambition to use the technology and whether mobile technology has positive or negative impacts on the environment. Moreover, it has been demonstrated that Technology Aided Modelling (TAM) provides the basis to determine the effects of the variable on attitudes. Barki and Hartwick (1994) empirically supported that users' attitudes lead to the intentions of use and the actual user of the new system. Thereby attitudes can provide a perspective framework for understanding the learner's intention of usage and acceptance of new technology. The successful proliferation of the M-learning community needs a sustained activity to examine the needs, wants, and preferences of theoreticians and practitioners through usability analysis towards establishing a framework of wider comprehension of M-learning users' attitudes and perceptions.

2. THE RESEARCH PROBLEM

Learning context faces different challenges in terms of user interface design as mobile devices have some limitations i.e., small screen size, different screen width among devices, touch screen capability, text typing difficulties, and limited attention to user and physical environment. Besides, there are some specific hardware issues including limited battery power, limited computing ability, limited bandwidth, and limited storage or memory which affect the designing of mobile learning applications. These challenges constantly affect the design of mobile learning applications. The learning content should be small enough to fit on the device's screen without giving up quality information. One of the solutions to overcome the challenge is to design a proper user interface. General indicators like the linearity of information and the importance level of information can be used to measure the quality of the user interface. The user interface should adapt to various sizes of the device's screen. The screen size requires a specific arrangement of information to be displayed to convey the information effectively. The study employs a systematic literature review method to extract insight from already published research works available on the research database. There are major limitations arising due to implementation problems of different user interfaces in M-learning for different mobile device platforms as the learning perception of potential end-users of M-learning are not extensively captured using direct practical engagement and participatory usability analysis across a wide range of university-level curriculum in the educational spectrum, which this study aims to achieve.

3. JUSTIFICATION OF THE IMPORTANCE OF THE PROBLEM FOUND IN PAST RESEARCH AND PRACTICE.

Usability analysis of user interfaces prior to the development process of M-learning applications has a major role in determining the learning attitude and perception of end users. Kukulska-Hulme (2005) reported that most of the M-learning applications have device compatibility issues occurring due to variations in the user interface from different manufacturers leading to further usability issues that make M-learning unfit for the purpose. The general issues include too much variation in the interfaces (e.g., keyboard size and arrangement) by different manufacturers, new models of devices being released too often (which imposes negative effects on the interface learnability), the need for frequent recharging, poor memory processing power of the devices (causing the applications to operate too slow), etc. Some discipline-specific issues—found to be a problem in, for example, accountancy (spreadsheets display and data entry) and music composition education—are too small and poorly lit displays and keyboards that are too compact. Due to the above-mentioned hardware issues—most devices are extremely portable and mostly come with a very small display screen and keyboards that cannot handle complex user interaction and navigation systems without causing disappointment to the user. There were several deficiencies in existing knowledge about the problem. Although there have been qualitative analyses of the use of mobile devices in education, systematic quantitative analyses of the effects of M-learning due to differences in user interfaces based on different mobile device platforms were lacking in the existing literature. The lack of proper usability analysis based on the ease of use of the M-learning applications arising due to multiple user interfaces inspires to fill the void in the existing literature. Further efforts are needed to broaden and systemize the relevant body of knowledge related to usability issues during the development process of M-learning applications. The audiences get benefitted from the study of this problem in several ways. The findings could become a layover platform for future researchers, mobile developers, educators, practitioners, and policymakers for future reference in the realm of M-Learning regarding the latest trends of usability analysis prior to the deployment of M-learning apps.

4. THE PURPOSE STATEMENT

Higher education institutions are responsible for providing convenient infrastructure for all students and should highlight higher-level interactions that entail a significant change in an information and communication-based society. Mobile technology is given an excellent avenue for an outside-classroom engagement. With an increasing number of educational applications, a better user experience while using the application was needed. The rational justification for the research problem was the need for the application's usability to be evaluated with suitable usability evaluation methods. Both efficiency and effectiveness of the application's usability were thought to influence user satisfaction of any mobile application. The assessment of usability involves evaluating the core concepts of web accessibility features requiring an impartial view of consistency. Literature indicates that traditional usability evaluation concepts mainly involve user activities and their efficiency in task completion, that is the functional dimensions of the interaction between user and product. Usability evaluation or research depends on the measurement of how people communicate with a specific product or service. Therefore, it was identified that usability evaluation, or usability testing, was mainly used for assessing the users' interaction with a particular application or product. The purpose of the study is to evaluate the application's usability to be evaluated with suitable usability evaluation methods. Among the challenges of user interface design involves a wide range of usability aspects such as navigation, content usefulness, and user experience.

The purpose of this research was to determine how the different types of user interfaces based on the mobile platform used in M-learning can enhance learning attitudes and perceptions for students following the 'Graphic Design' curriculum of respective undergraduate-level courses of university studies by performing a usability analysis of multiple user interfaces used in M-learning using both Apple iOS and Google Android platform. Moreover, research has found that M-learning produces a significant impact on the learning attitude of students (Jin Xue, Xue Zhang, and Heng

Luo, 2017). The independent variables to be used while conducting the randomized experiment is the device features based on the mobile platform used in the M-learning mode of instruction delivery while the dependent variable is the learning perception of university students.

5. Assumptions and Hypothesis

It is hypothesized that mobile device user interfaces that provide better ease of use, flexibility of usage, and immediacy of information acquisition leads to better learning attitude and perception among undergraduate university students.

6. Research Question

To address the hypothesis, it was sought to answer the research question of how the different features of a user interface used in M-learning affect the factors - like the ease of operation, the flexibility of usage, and immediacy of information acquisition which are used to judge the learning attitude and perception. Additionally, the researcher qualitatively determines how the type of mobile device used in mobile learning can cause a change in the effectiveness and accessibility of learning activities.

7. Research Significance

Determining the compatibility of M-learning applications with a wide range of potential device configurations is of major significance as some M-learning application features are not available on all devices. For example, some devices may not include a compass sensor. If your M-learning app's core functionality requires the use of a compass sensor, then your app is compatible only with devices that include a compass sensor. In determining the usability of quality attributes for any mobile applications, the application developers should determine whether the end-user finds the application user-friendly and attractive, and the extent to which the product is understood, and simple to operate. Determining usability also involves functional testing. Inspection, review, and evaluation, which are to be performed on the M-learning applications as a part of the usability verification technique.

8. REVIEW OF LITERATURE

Mobile devices offer individualized and personal experiences. Laurillard and Sharples (2007) agreed that mobile devices offer five advantages for education: portability, accessibility, learning opportunities, connection, and personal experience. Kukulska-Hulme (2020) noted that Mobile-Assisted Language Learning (MALL) provides students with rich, real-time, convenient, social contact, collaborative, and contextual learning. Interactive Learning Network (ILN) model which involves both tablet PCs and wireless technology has been implemented for pre-and post-tests to assess the student's performance (Enriquez, 2010). Gikas and Grant (2013) highlighted the effects of mobile technologies on learning and teaching in accordance with social media in the form of Skype, Twitter, and Blogs. Glackin et al. (2014) addressed the integration of mobile devices and E-Books to raise the student's familiarity with a digital library. In addition, mobile phones have been used as a learning tool for teaching the French language at Princess Nora University, Saudi Arabia. (Jaradat, 2014; De Pablos et al., 2015) conducted two studies to examine the usage of iPads during one semester in a Mathematics course. Hamza et al. (2018) emphasized how learning context faces different challenges in terms of user interface design as mobile devices have some limitations i.e., small screen size, different screen width among devices, touch screen capability, text typing difficulties, limited attention to user and physical environment. Besides, there are some specific hardware issues including limited battery power, limited computing ability, limited bandwidth, and limited storage or memory which affects the designing of mobile learning applications. These challenges constantly affect the design of mobile learning applications. The learning content should be small enough to fit in the device's screen without giving up quality information. One of the solutions to overcome the challenge is to use a mobile device with the proper user interface. General indicators like the linearity of information and the importance level of information can be used to measure the quality of the user interface. The user interface should adapt to various sizes of the device's screen. The screen size requires a specific arrangement of information to be displayed to convey the information effectively.

Fig 1: *Literature-Map derived based on literature review.*

The study employs systematic literature review method to extract insight from already published research works available on the research database.

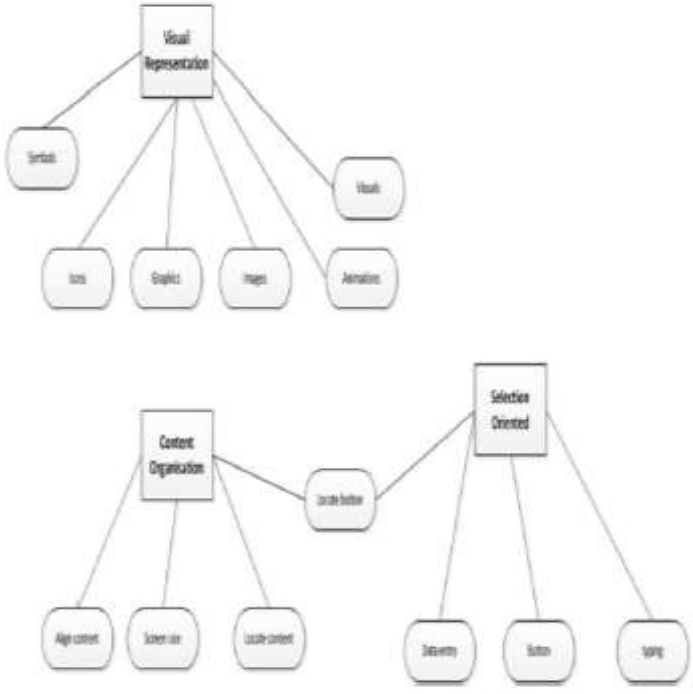
This research paper focuses on usability analysis and testing of mobile applications used in M-learning will help to extend the literature by helping future researchers and developers to ensure that the M-learning application under consideration is used by different types of persons ranging from IT experts to students and disabled.

9. RESEARCH METHODOLOGY

This qualitative study employs content analysis methodologies to review and gain insight from the literature. The research design involved a qualitative coding method to

search for the related keywords, detect themes related to the keywords, and categorize the keywords into specific themes. The extraction process is automatically done using macro add-ons for word processors. Open coding involves finding a representative concept for each sentence. These concepts were then coded into three themes. The themes were based on the following concepts of mobile learning, i.e., mobility of technology, mobility of learning, and mobility of learner. Each sentence is matched with one of these three concepts. Lastly, the framework was formed based on the result of the coding process and related literature. The authors make assertions on the purpose of the study based on literature reviews where the mobility of technology means that the devices used to deliver learning content should have the ability to connect to the Internet so that the information is able to be accessed anywhere and anytime by students. Second, the mobility of learners means that the learning activities need to be able to support the students' mobility as well as the freedom to access the learning material based on their needs. Third, the mobility of learning indicates that the material contents need to be adjusted to be more suitable for mobile devices. The sampling process consists of extraction from 42 papers, 222 valid sentences that contain the "interface" words are selected and coded. Data Collection source for analysis was previously published works in a journal database enabling the researcher to conduct the study enabling further research ability to duplicate the outcome in a higher education environment.

Fig 2: *Thematic Map of Usability Issues*



10. DATA ANALYSIS

The papers under review were sorted into categories. The distribution of articles was based on the publication year. The study of mobile learning began to emerge in 2011 upwards. In 2014 the number decreased slightly before reaching a peak a year later. Overall, the amount of research on this topic is still increasing from year to year. Students were the most frequent users of mobile learning as almost 30 percent of the papers were discussed in this context. To give the study findings better content validity, suitability, dependability, and quality, triangulation of data was performed using students' feedback on ease of use, flexibility of usage, and immediacy of information acquisition for the selected user interface design based on two different device platforms for comparison. From the data depicted in Table 1 below, it is evident that when the quasi-experiment was done based on repeated measure design for the target group of 16 students, the iPad depicted better adaptive capability due to a better user interface and students had a better learning attitude with iPad devices.

Based on the questionnaire data, this study employed the Friedman Test to compare students' attitudes toward M-learning using the iPad's user interface and the Android tab user interface. The i-Pad user interface of M-learning mode received higher ratings on learning attitude and the results suggested that the i-Pad user interface was superior in terms of content organization and promoting better learning attitude among undergraduate students. However, it is interesting to note that the Android tab user interface received significantly lower learning attitude ratings on some items indicating students preferred the i-Pad user interface for M-learning instruction delivery.

Table 1: Student Response based on closed-ended questionnaire for iPad.

iPad Features / Characteristics	***Type of Device Service for iPad***	***Student Count***	***Student Percentage***
The immediacy of information acquisition due to the adequacy of memory	Very prompt delivery	12	75
	Prompt delivery	2	12.5
	Not prompt delivery	2	12.5
Flexibility of usage due to Battery Life	Very flexible to use	12	75
	Flexible to use	3	18.75

iPad Features / Characteristics	*Type of Device Service for iPad*	*Student Count*	*Student Percentage*
	Not flexible to use	1	6.25
Size of the Display /Screen attractiveness to accessing learning content like video, audio, and text	Very Attractive to Use	11	68.75
	Attractive to Use	3	18.75
	Not Attractive to Use	2	12.5
Keyboard Size and arrangement in ease of use	Best Ease of Use	10	62.5
	Easy to Use	4	25
	Poor Ease of Use	2	12.5

Note: Table 1 identifies the percentage of students who accepted the user interface based on the iOS mobile platform

Based on the questionnaire data, this study employed the Friedman Test to compare students' attitudes toward M-learning using the iPad's user interface and the Android tab user interface.

Table 2: Student Response based on closed-ended questionnaire for Android tab.

Android Tab Features / Characteristics	*Type of Device Service for iPad*	*Student Count*	*Student Percentage*
The immediacy of information acquisition due to the adequacy of memory	Very prompt delivery	9	56.25
	Prompt delivery	4	25
	Not prompt delivery	3	18.75
Flexibility of usage due to Battery Life	Very flexible to use	8	50
	Flexible to use	4	25
	Not flexible to use	4	25
Size of the Display /Screen attractiveness to accessing learning content like video, audio, and text	Very Attractive to Use	7	43.75
	Attractive to Use	4	25
	Not Attractive to Use	5	31.25
Keyboard Size and arrangement in ease of use	Best Ease of Use	5	31.25
	Easy to Use	6	37.5
	Poor Ease of Use	5	31.25

Note: Table 2 identifies the percentage of students who accepted the user interface based on Android platform

The i-Pad user interface of M-learning mode received higher ratings on learning attitude and the results suggested that the i-Pad user interface was superior in terms of content organization and promoting better learning attitude among undergraduate students. However, it is interesting to note that the Android tab user interface received significantly lower learning attitude ratings on some items indicating students preferred the i-Pad user interface for M-learning instruction delivery.

QUESTIONNAIRE ITEM BASED ON THE FRIEDMAN TEST OF STUDENTS' LEARNING ATTITUDE

The Friedman test is used for one-way repeated measures analysis of variance by ranks and this procedure assumes that the original observations are measured on at least an ordinal scale (Richardson, 2018).

1. The instructional content was clear to understand

2. The instructional content was well organized.

3. The instructional content was presented in diverse formats.

4. I can adjust my learning based on my mastery of content.

5. I can adjust my learning process based on the type of content.

6. I can selectively choose the instructional content to be studied.

7. The format of instruction increased my interest in learning.

8. I will study more if the next class takes the same format.

9. I would recommend this format of instruction to my peers.

10. I can actively discuss academic content with the instructor.

11. I acquired relevant information immediately during learning.

12. I gained more opportunities to communicate with my peers

13. I can comprehend the instructional content.

14. I can think independently during my learning process.

The source of analysis was primarily based on the results of a 5-point Likert scale questionnaire. The evaluation received several positive feedback from the participants concerning their issues for improvement purposes. Usability was analyzed by determining the ease with which the students could access the service with minimal complexity and optimum satisfaction while meeting the desired goals. The efficiency of the mobile application was found to be at a moderate level and most of the participants were satisfied with using the same application.

11. DISCUSSION ON FINDINGS

The first step of the coding process generated 91 open codes from 223 sentences. These 91 concepts were then mapped into three dimensions of mobile learning. The codes were categorized as dimensions for learners, learning, and technology. The sentences on the 'user interface' topics were then coded further to identify the themes. The result shows that there are four dimensions of the user interface based on four themes generated - Design Principle, Hardware specifications, Context of usage, and Modelling Language to support the researcher's argument. The use of modeling language in designing a mobile learning application's user interface is important. It deals with the modification of the design during the development as well as the improvement phase of the application. An object-oriented approach was suggested as modeling language in user interface design. There are specific modeling languages that can be employed to design user interfaces, such as the Interaction Flow Modelling Language and Unified Modelling Language (UML). The findings depicted an extent of visualization of the outcome to strongly support how it correlated to the aim of this study. Some issues arose due to the unsupported operating system platform and device condition or age span. While device allotment. Additional issues related to participants' confusion led to dissatisfaction despite many positive comments. The limitation of this study is the inexistence of exploring the potential factors that may determine the behavioral intention toward the adoption of a campus service application.

12. REFLECTION AND SUMMARY

Recent technology supports collaborative work among users which is becoming a more important feature in mobile learning. Additionally, the layout of any user interface for any type of mobile platform should highly consider the screen size of the device so that it can be displayed properly. Doing learning activities through mobile devices is not dependent on time and place. It has limited aaffectn from the users which affects the level of the user's concentration in doing tasks. Therefore, the interface should be designed based on the user's context, especially on their mobility. This article shall be useful to future researchers on how user interface plays an important role in mobile learning system development. It reflects on the way the user interface of the application would be developed and the adoption process or user acceptance. Future studies are needed to provide comparative results after some interface improvements were suggested based on this study and successfully identified the determinant factors of behavioral intent to use the higher education mobile application.

13. AVAILABILITY OF DATA AND MATERIAL

To ensure compliance with the current regulatory requirements set forth by the place of research, an application to request approval from the Institutional Review Board (IRB) was submitted. To ensure confidentiality, all respondents provided their electronic consent before participation in the study. The name of the app used for evaluation was kept confidential to avoid legal issues. The app was considered good in terms of effectiveness. Based on the time taken to complete each task, it can be concluded that the app is efficient for use. The data for the study was secured on a personal laptop computer hard drive and personal flash drive. During data collection, the researcher asked only protocol interview questions and avoided leading inquiries. Throughout the process, multiple diverse perspectives were reported, and data was kept transparent.

14. ACKNOWLEDGEMENT

The researcher requested participation from the participants after explaining the purpose of the study. Due credit was given to all research subjects in writing after the research data collection. All communication with research subjects was conducted via institution-affiliated email/video chat following 2021 COVID-19 social distancing recommendations and to prevent legal risks of participation. The researcher hereby declares that the information furnished above is true, to the best of her knowledge.

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