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The Taxonomy Mobile Learning Applications in Higher Institutions of Learning in Ugandan Universities: A Case of Kabale University, Uganda.

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Abstract: Since the use of mobile devices outpaces that of laptops and desktop computers today, the usability of these mobile devices is an important consideration. When mobile learning (a new kind of electronic learning) takes shape, bringing an important feature of mobility, the trend expands deeper into teaching and learning. Usability describes the quality characteristics of software product usage; hence, usability testing is a crucial concern in developing companies for the success of product deployment and use. The vast majority of existing usability evaluation approaches were created for desktop software development. As a result, currently existing models do not specifically address mobile learning, presenting a gap that we aimed to remedy. The study developed a model that estimates usability as a function of aggregated usability influencing factors. To provide a more comprehensive model, the proposed model includes essential features from other accessible models and incorporates the majority of those that assist mobile learning. A mobile learning prototype application was designed, tested, and installed to evaluate the efficiency of the developed model, coupled with a task list for objective research. Using a sophisticated statistical technique, the feedback from the experiment and survey was then utilized to assess and validate the prototype application in terms of high, average, or low usability. The findings act as guides for eLearning developing businesses to create more relevant mobile learning applications with high levels of usability.

Key Word: **E-learning, U**sability, Software Quality; Prototyping; Objective test; Subjective test

I. Introduction

The desire for learning at any time and from any location has defined the need for mobile learning (m-learning), recognizing the use of mobile devices (laptops, personal device assistants, and smartphones), which are becoming increasingly popular (Jung, 2014). The primary features of mobile phones, including hardware and software, are their mobility, performance, and usefulness. The mobile learning environment is incredibly fluid. As a result, mobile learning applications can vary widely depending on the environment and scenario, ranging from basic to advanced schooling and other corporate learning contexts, as well as formal and or informal learning to classroom learning, distant learning, and field research. Some of the software and mobile applications have been designed specifically for educational purposes, but most are off-the shelf solutions originally intended for other uses like business use. Usability is context-dependent. This means that software with high levels of usability in one context may have poor levels of usability in another. The application context encompasses the software's tasks, the environment in which it is used, and the users who complete tasks with the software. (Park, 2011)

Mobility of the learner has not been catered for greatly as developers sometimes overlook the fact that users always will want to interact with such devices while on the move. Small screen sizes, limited connectivity, high power consumption rates and limited input and output modalities are just some of the issues that arise when designing for small, portable devices. And this limits mobility. Mobile learning exploits both handheld computers and mobile telephones (smartphones) and other devices that draw on the same set of functionalities but it is relatively immature in terms of both its technologies and its pedagogies, though it is developing rapidly. This draws on the theories and practices of pedagogies that are used in technology that enhances learning and others used in the classroom and the community. When designing desktop computers and applications, many usability guidelines are used. However, these guidelines cannot be utilized to design and develop smartphones and mobile applications, and this is because they do not address the issues related to mobile phones and mobile phone applications and their current limitations. “There is a lack of good-quality usability guidelines for designing and developing mobile applications,” (Ali, 2013).

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The mobile applications provide convenient access to your course on the Portal. However, there are a few limitations and restrictions to be aware of: for example, Blackboard mobile apps should not be used for taking assessments including tests, quizzes, surveys, and assignments: Instructors should use a personal computer to upload course files and content, create tests and quizzes, and post grades: Some media types and file formats may not display on certain devices: Notifications and course updates may be delayed depending on factors such as your network provider or connectivity (Johnson, 2015)

However, mobile learning should cater for the following; learning on the move, herein referred to as mobility, good display features with quick access features of navigation, flexibility in data input methods and output features; one needs not constrain his/her eyes to work with the app features. One should be able to only be online to update the course contents then thereafter work offline and later be online again to update the web content, but not always work online (Sarker, 2003). Therefore, with the existing applications and their limitations, especially the mobile learning usability issues of the apps, better guidelines for app development are a necessity for the developing organizations to produce better quality mobile software products and hence more usage of the apps in teaching and learning (Ali, 2013).

II. Problem Statement

Mobile learning is distinguished by its capacity to foster significant engagement between lecturers and learners which fosters more motivation, convenience, cooperation, and flexibility in the learning process. In this setting, mobile learning environments have arisen as a tool to assist m-learning projects. Despite their importance, there is no comprehensive and well-defined list of standards for such systems. Also, these programs have usability limitations: There are interactivity issues with mobile applications, such as difficulty in data input by the user, as well as limited data input methods and output limitations in terms of methods, media format support, and application interfaces that are unappealing, difficult to learn and navigate, with limited customization functionalities and missing features, all of which present usability issues to the user and thus hinder mobility. Furthermore, in addition to apps that rely on distant connections to web servers, which is neither comfortable nor cost effective, most applications need pricey supporting features and periodic upgrades, without which they cannot function properly or at all. Moreover, the continual crashes, hanging, and obsolescence of certain mobile applications raise worries among end users, confining and limiting use. As a result, there has been a significant requirement for usability quality in order to stimulate usage in learning and other productive activities, limit resource depletion, prevent waste, and mitigate related human and social costs and dangers. This may be accomplished by usability testing and adherence to facts by establishing firms. The researcher developed model to test a prototype of an environment in an objective experiment, results were analyzed and recommendations published as application development as guidelines.

III. Related Literature

Usability and its related issues have been a key area of research for electronic learning in general, and m-learning in particular (Ouda, & Capretz, 2012). Usability has previously been less extensively covered than the technological aspects of the mobile application development for learning. Studies have also revealed that usability issues have a great impact on the success of mobile phone applications; however, there is a lack of research about learnability, understandability, ease of use, effectiveness, and efficiency of mobile applications—all aspects of usability (Abran, , et al. 2004).

Usability, according to ISO can be measured in terms of three attributes; effectiveness, efficiency and satisfaction. Other attributes, such as cognitive load, security, tend to be overlooked in the usability models that are most prominent despite their likely impact on the success or failure of an application. It is apparent that many existing models/frameworks for usability do not consider the mobility factor and its consequences, such as additional cognitive load.

Most mobile learning apps are web based. Generally, web-based application functionalities are dependent on ability to access to the Web servers. Whereas there are many practical reasons why these requires an access to the data on server, every feature of an application may not necessarily need to have such real-time access. Therefore, it may be possible to enhance the user experience and wider applicability of the application by providing offline access to certain features (Masters, 2004, Vavoula, & Sharples, 2009).

Moreover, there are only a few studies targeting quality issues in educational tools and m-learning applications of smartphones and there is a lack of research about the usability of mobile devices and applications for learning (Harrison, and Duce, 2013), an issue the researcher endeavored to explorer. This study aimed to fill in some of the gaps that currently exist in the research on usability of mobile applications and also help to build a foundation for future research in mobile learning.

The models presented above were largely derived from traditional desktop applications. For example, Nielsen's work was largely based on the design of telecoms systems, rather than computer software. The advent of mobile devices has presented new usability challenges that are difficult to model using traditional models of usability. Zhang, 2006 highlighted a number of issues that have been introduced by the advent of mobile devices:

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Mobile Context: When using mobile applications, the user is not tied to a single location. They may also be interacting with nearby people, objects and environmental elements which may distract their attention: Connectivity: Connectivity is often slow and unreliable on mobile devices. This impacts the performance of mobile applications that utilize these features: Small Screen Size: In order to provide portability mobile devices, contain very limited screen size and so the amount of information that can be displayed is limited: Different Display Resolution: The resolution of mobile devices is reduced from that of desktop computers resulting in lower quality images: Limited Processing Capability and Power: In order to provide portability, mobile devices often contain less processing capability and power. This limits the type of applications that are suitable for mobile devices: Data Entry Methods: The input methods available for mobile devices are different from those for desktop computers and require a certain level of proficiency. This problem increases the likelihood of erroneous input and decreases the rate of data entry.

The design and development of mobile learning application with no doubt is hard process which needs software programming knowledge, graphic design knowledge, instructional design knowledge, content localizing. Wang and S. Dey, 2012 argued about characteristic virtual learning environment. “They permit students to experience high levels of presence, they are interactive and they are autonomous” (Hanson & Shelton, 2008). Based on mobile application flexibility some educational institutes, universities or schools started to develop specific mobile applications for their students according to their curriculum and particular need. In 2010, Princeton University implemented their mobile learning services. Through this service and students can have “Access documents in multiple formats, post announcements, create threaded discussion posts, upload media as attachments to discussion boards and blogs, create content items within the course map, ...take tests, and receive push notifications for important course updates or changes” (Tapanee, 2012; Alden, 2013).

However, some researchers suggested that there must be learning strategy in design and development phase such as active learning, collaborative learning, authentic learning and multiple perspectives (Karagiorgi & Symeou, 2005). Although there many research in mobile learning but recent research shows that there are priorities in research which can have effect on better design and development phase. “a) teaching and learning strategies; b) affordances; c) theory; d) settings of learning; e) evaluation/assessment; f) learners; g) mobile technologies and interface design; h) context awareness and augmented reality; i) infrastructure and management; and j) country and digital divide.” (Nassuora, 2013; Hsu et. al, 2013)

IV. Material and Methods

Study Design: Because usability is subjective, it is a non-quantitative condition that necessitates sampling and statistical analysis: To identify a link between usability of a learning application, its usage, and application for mobile learning, usability evaluation was done with a knowledge of the gap between user expectations and attribute performance judgments.

Sample size: 13 participants in the quasi experiment from the Faculty of Computing, Library and Information Sciences, Kabale University Uganda.

Subjects & selection method: The non-probability sampling approach was used to choose the respondents for the study. The "convenience sample" is non-probability sampling. Convenience sampling involves respondents who are easily accessible, saving the researcher time and money.

Inclusion criteria:

The sample population for this research study comprised Kabale University personnel and undergraduate students. The population was limited to second- and third-year undergraduate students as well as faculty and employees from the Faculty of Faculty of Computing, Library and Information Science

Exclusion criteria:

1. Students who did not own any mobile devices or smart phones
2. Staff who did not have smart devices
3. Students who were not yet in their second year of course

Usability framework development

According to the researcher's review, most existing models for usability do not consider mobility and its consequences, such as increased cognitive load in addition to safety and privacy, complicating the job of the usability practitioner, who must consequently define their task model to explicitly include mobility. One may argue that the absence of reference to a specific context is a strength of a usability model if the usability practitioner takes the initiative and knows how to change the model for a specific environment. However, in comparison to the preceding, mobile learning is distinct in that the practitioner's knowledge of the context is limited and the environment is dynamic; thus, the researcher believes that incorporating mobility, as evidenced by the level of learnability,

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operability effectiveness, and understandability, in mobile learning application context allows designers to produce high-quality software with maximized usability attributes.

Based on the facts presented above, the researcher developed a more comprehensive criterion tool for usability measurement, which incorporates several usability factors derived from various existing frameworks, including Learnability, understandability, Effectiveness, Efficiency, Serviceability, Operability, and Satisfaction. Because all important features offered by the mentioned models are contained inside this model, the researcher feels that the attributes listed above may be used to test usability and produce full and satisfying findings.

Table 1.2 Usability framework

Interactivity Navigation /Orientation Multimedia usage Feedback		**Effectiveness**	Usability	Mobile Learning
Input/output ability		**Understand ability**		
Time required Effort required		**Efficiency**		
Help/ Support Cognitive load Learning potential		**Learnability**		
Customizability/ Personalization Error tolerance User control Readability		**Operability**		
Technical support Upgrades Guarantee				
Engagement Screen layout Screen Design Safety/privacy	Attractiveness Security			

The created usability evaluation framework was expanded in detail, as shown above, to cover the sub-factors of the usability attributes. According to ISO-9241, the various qualities were subdivided into matching sub-factors. As indicated in the next section, the many sub-attributes offered a better platform for producing measurements against the user goals.

Objective test instrument design

In addition, to develop the objective study task list, the model for measuring usability factors developed in this study includes a combination of different usability sub-characteristic as shown in the conceptual framework, which were considered to develop an objective criterion task list and an evaluation questionnaire which was entirely subjective. This involved face to face interaction and hands on experience under the research assistants and the survey respondents.

Objective measures were one of the tasks done to test the prototype application developed in what was considered an experiment before it was taken into the field for the subjective study. This was done by employing 13 people who evaluated the app based on the objective metrics.

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Table 1.2 Object list metrics

Task list	Task List
1. Check for interactivity a) Check of user interaction with application b) Check of availability of communication tools c) Check of usage of gestures 2. Navigation activity a) Check of main menu presence b) Check for scrolling c) Check for hierarchical menu d) Check for navigation keys 3. Check for adequacy of feedback a) Response to input b) Audio instructions 4. Check for time a) Loading application b) Task completion 5. Check input/output availability a) Virtual keyboard	6. Check for adequacy of Help a) Task related clues b) Tutorials c) Help icon 7. Check for cognitive load a) Identify a link or icon usage b) Check for suitability of language c) Check for suitability of content 8. Check for learning potential d) Check for presence of alternative learning options e) Check of assessment / result availability 9. Check for personalization/customization a) Check for availability of settings option 10. Check for short error messages 11. Check for user controls 12. Check suitability of reading

Observations were made as the user interacted with the application and test results were recorded. The tests involved having the user to try and accomplish some tasks for example, login, register, find course, view course details, et cetera.

Prototype development and data gathering overview

To understand the usability of mobile learning mobile applications, the researcher developed an application prototype. The prototype was then a basis for evaluation of usability. This helped to gain insight about how a mobile application can be used by students and instructors. Having the prototype tested and then evaluated in an experimental objective study.

Prototype development and testing

Following a Mobile Application development lifecycle, we designed and development our prototype through Identification phase where emphasis was put onto the context of the application use and teaching and learning were a core entity for the development of the application; design phase where the idea was developed into an initial design of the application. Application design and Modeling and implementation.

The Prototype development life cycle

A Software development lifecycle process is a type of structure or framework used in the development of any software product. There are many different lifecycle models defined. Waterfall model, spiral model, prototyping model are a few such models. Each model is described by a sequence of activities. The development steps or the activities may vary in each and every model but all the models may include planning, requirement, analysis, design etc.

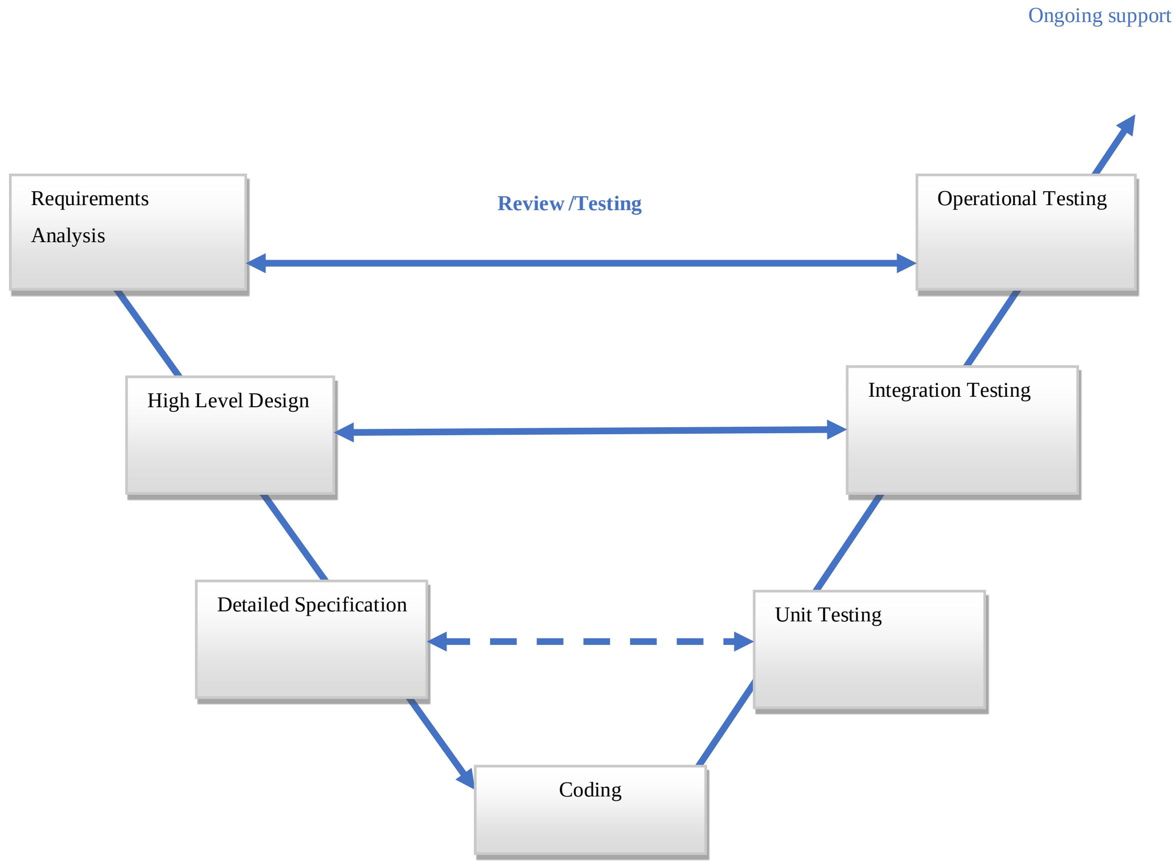

Fig 1.1 Software development life cycle.

The figure above shows a general software life cycle. However, the prototype in question is a mobile application for learning and therefore a more convenient life cycle model was the mobile application development life cycle

Mobile Application Development Life Cycle (MADLC)

Identification Phase

In the first phase, ideas were collected and categorized. The main objective of this phase was to come out with a new idea or improvements to the existing applications. Most ideas came from the different published literature, and journals and publications by researchers, users and developers. If an idea came out, the idea was further detailed and analyzed. The existing applications on any of the standard's platforms were searched to establish the novelty of the idea. Also, emphasis was put onto the context of the application use and teaching and learning were a core entity for the development of the application.

Design Phase

In this phase, the idea was developed into an initial design of the application. The feasibility of developing the application on all mobile platform was determined. And alternatively, the specific target mobile platform (android OS) was identified. The design process involved the use of Unified Modeling Language to develop both the structural system where class diagrams were used for the different classes required and the behavioral or dynamic view of the system was designed using use case diagrams and activity diagrams.

Application design and Modelling

Prototype development models:

In the section below, the researcher explains some the design models for the prototype design.

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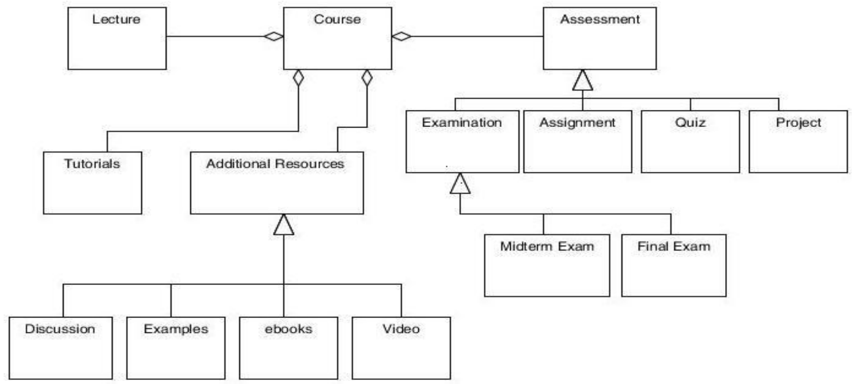

Fig. 1.2 Course dependencies and relationship model

The model shows the generalization and aggregation dependencies on course, that is, course Lecturer/instructor, Course tutorials, Course Additional resources and Assessments.

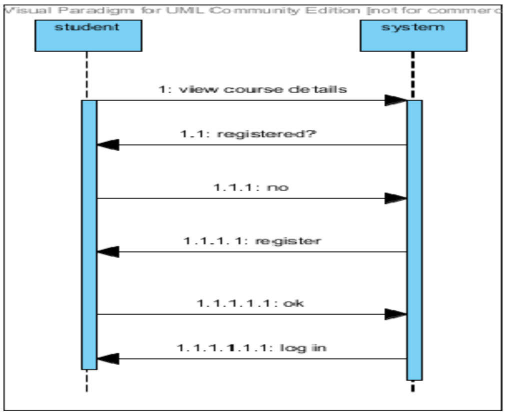

Fig. 4.41 Sequence diagram showing the student view

The student can only view course but not course details unless he/she is logged into the system. If the student is not registered yet, he must first do so and there after login to get access to view and manage (limited privileges) a course as granted by the administrator.

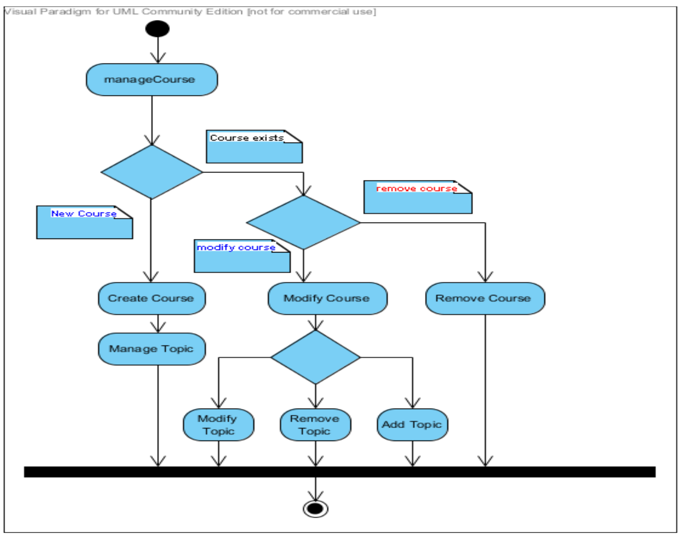

Fig.1.3 Activity diagram for course management;

The diagram above shows different tasks that can be performed by administrators and instructors

A use case diagram showing teacher and student roles

After modelling was done, coding started to make a real android application. Some of the screens from the implementation on actual android devices are shown below.

Development Phase

In this phase, the application was coded. The coding for different modules of the same prototype proceeded in parallel. The code was developed first for the core functionalities. Parallel development was done for modules of the prototype that are independent of each other. Subsequently, these modules were integrated.

Prototyping Phase

In this phase, the functional requirements of each prototype modules were analyzed; the prototype modules were tested. With the development environment being android studio, a collective development of the interface in xml, and the application functions in java was done concurrently, and automation of the application checks and system debugging are done instantly through building, rebuilding and cleaning the app as development is ongoing. This is one of the biggest of android studio 3.1.

Testing Phase

Testing is one of the most important phases of any development lifecycle model. The testing of the prototype types is performed on an android emulator/simulator followed by testing on the real device. The emulator/simulator is provided in the SDK. The testing on the real device was done on android based devices of different versions with variable screen size and power.

Deployment Phase

Deployment is the final phase of the development process. After the testing was completed and the final feedback obtained from the different user and developers, the prototype was ready for the deployment. The figures below show the different screen shots of the application during the deployment on a real device, that is, smartphone for the android platform.

Prototype Implementation and Testing

The prototype, which is solely a teaching and learning environment, was implemented and evaluated during this phase. This was done primarily to assess the prototype's usability. This evaluation mechanism included face-to-face interaction with the respondent while using the prototype and making observations, as well as the use of developed data collection tools that adhered to the mobile learning application usability measuring criteria and were developed with respect to the framework developed from the usability framework. In this study, the researcher verified that the context of measurement corresponded to the context of use, i.e., mobile learning, by ensuring that the circumstances for the usability test were indicative of the main components of the overall context of use, i.e., mobile learning. In this study, mobile learning is evaluated when mobility with its increased cognitive strain is prioritized. The learners' ease of doing tasks to reach one's goals while using the mobile learning application and on the move is taken into account.

Procedure methodology

Choosing tasks, users, environments

The users, tasks and environments selected by the researcher greatly depended on the objectives of the evaluation which aimed to determine the level of usability of the mobile application prototype. Therefore, learning was considered to take place both in and outside classrooms and while the user is mobile or on the move and noisy environments, with the additional cognitive load which impacted performance of user tasks.

The evaluation in this study aimed to measure the level of usability while considering application interfaces in terms of input, output features, customization and others as shown in the conceptual framework. The different tasks of creating, modifying, deleting a course, enrolling for a course, customizing the user interface, finding course, course peers, and sharing were considered to be more coherent tasks to the context of this study. Each task was performed separately until completion if possible and the amount of time and effort required for the task completions and errors generated and recovery times were recorded.

The respondents then had to fill the usability questionnaire to record their perception and experience while using the prototype application. The respondents' perceptions and experiences were noted following the usability theoretical framework developed to evaluate usability. The framework comprises of comprehensive factors of usability measurement of mobile applications and more so on the usability of mobile learning applications.

The objective test

As suggested by Bevan, 2006, a minimum number of eight to ten participants are generally required in order to make reliable estimates to uncover the usability problems of an interface, a total of 13 respondents were employed in this test. Before usability testing a consent form was signed by respondents to participate in the study. All participants were required to complete 12 tasks with the app. The participants were given time to freely explore the application before completing the tasks. The participants were given a brief introduction in the start regarding the purpose of the study.

Tasks were developed using objective metrics in order to collect objective data and questionnaire was developed using subjective metrics to obtain results for subjective measures assessing satisfaction ratings with interface design. These developed instruments can be used in usability evaluation of educational apps for learners and teachers by implementing tasks performance for objective measures and using questionnaire to assess the subjective measures. It should be noted that user satisfaction is not simply correlated with performance measures such as task completion time and grade but rather can be measured from user perceptions and attitudes towards the application.

The prototype was implemented and tested where 13 respondents were chosen, and used the prototype while carrying out specified tasks to complete a list of certain activities (tasks), with each respondent having a different smartphone with different specifications. After installing the prototype application, the process of loading the app was evaluated including how much time, memory and processing power were consumed during the process. Thereafter, the 12 tasks had to be performed by the respondent: creating a course, enrolling in a course, changing user role, modifying a course and customizing interface. The tasks were performed while paying attention to the task list as developed in the methodology.

The respondent further was tasked to respond the Usability task list which comprised of major 24 quiz. For these tasks, the teachers/instructors were used as respondents because of their expertise in Information and technology and are well conversant with smartphone and mobile learning environments. This helped the researcher in this study to achieve more accurate and correct results. The results from the test were aimed at measuring the effectiveness, Efficiency and Satisfaction which are the core three factors of usability of mobile applications according to ISO and IEEE and hence the mobile learning prototype application.

The tasks considered for this study were divided into user goals which included; launching the application, user sign-up, user login, changing user role, searching course, enrolling for course, Un-enroll from course, download material, upload material, Read material, comment and sign-out. The task in this study were given the attributes of; task breakdown, task name, Task goal, Task frequency, Task duration, Frequency of events, Task flexibility, Physical and mental demands, Task dependencies, Task output, Risk resulting from error.

For the tasks above, it was required of the user to assess the task execution requirements, that is, the criticality of the task output, the degree of precision required in output and the autonomy of the user in completing a task and with regard to task input, task output, task side effects, task dependencies, and linked tasks, and rate the task checks provided in the task list accordingly using a five-point scale below.

The five-point scale used to grade the tasks included;

Grade	Mnemonic Description
Very low	Failure, unable to complete a task
Low	Partially complete or high task completion time
Medium	complete Reasonable task completion time & effort
High	Complete task, less effort
Very high	Complete task with minimum effort

A log sheet with fields for task name, starting time, finishing time, and solution were provided to the test respondents. The data collected from the test included a detailed log of the respondent's interaction with the prototype application. The interaction log gives a timing account of the proceedings of the user with the app including task starting time, finishing time and solution recorded on the provided log sheets. From the test results, efficiency and effectiveness of the prototype application were measured, where efficiency was measured as a task completion time, which was retrieved from the interaction log sheets obtained from the respondents after the experiments, and effectiveness was measured as the accuracy with which the efficiency was achieved in percentage.

V. Results Presentation

The researcher presents the data findings from the prototype test done under scrutiny and intense observation of user performance to measure effectiveness, efficiency and user satisfaction of the prototype application in the objective test and the survey findings acquired from implementing the structured questionnaire for the subjective test over the sample population. The questionnaire design ensured that the research findings thereof were converted from the subjective qualitative nature to quantitative data through coding using a five-point Likert scale and then analyzed using statistical package for social scientists (SPSS). The data is hereby presented in tables and, or charts as deemed more appropriate by the researcher, such as pie charts and bar graphs. The presented data corresponds with the usability factors presented in the developed theoretical framework.

Prototype Objective testing results

The prototype was implemented and tested where 13 respondents were chosen, and used the prototype while carrying out specified tasks to complete a list of certain activities as presented in the previous chapter. The results from the test were aimed at measuring the effectiveness, Efficiency and Satisfaction which are the core three factors of usability of mobile applications according to ISO and IEEE and hence the mobile learning prototype application.

Table 1.3: The objective test User-task completion time

	USER - TASK COMPLETION TIME												
TASK	User One	User Two	User Three	User Four	User Five	User Six	User Seven	User Eight	User Nine	User Ten	User Eleven	User Twelve	User Thirteen
Task One	9	11	11	12	9	6	10	8	13	6	10	11	9
Task Two	109	118	90	118	110	119	120	123	123	101	113	126	103
Task Three	61	65	54	60	60	40	51	40	54	48	71	58	61
Task Four	10	9	8	7	12	8	5	9	8	12	12	12	8

Task Five	50	41	48	47	61	40	61	53	50	61	66	73	62
Task Six	10	14	7	11	6	7	11	20	10	12	4	8	7
Task Seven	5	4	4	7	8	6	8	0	12	10	9	6	6
Task Eight	104	48	119	65	69	60	98	110	90	92	125	98	103
Task Nine	126	106	130	90	69	66	100	110	102	116	123	121	99
Task Ten	62	90	67	67	66	100	97	121	126	104	104	97	78
Task Eleven	128	113	108	108	86	71	102	106	63	91	100	101	112
Task Twelve	67	70	48	57	48	20	14	4	14	14	30	15	22

The table above shows that some users did not complete all the tasks. Since each task had to be completed within a limited range of time, the task(s) which was not complete by the end of the allotted time was considered a failure. In addition, the tasks which dependent on the preceding tasks could only be attempted by the respondents only if the previous task completed successfully.

From the objective test, user eight did not complete task six through task nine, user three did not successfully complete tasks, eight and nine, and finally user one did not successfully complete task seven and eight. From the Table above, user eight did not attempt task seven because it depended on the preceding task. A total of 156 task were to be attempted by the 13 respondents and were reduced by one, that is task seven which was attempted by all the rest except user eight. Of the thirteen users, 10 users managed to successfully complete all the tasks and only three could not complete all the tasks where user one completing 10 tasks and failing 2 tasks, user three successfully completing 10 task and failing to complete 2 tasks, and finally user eight failing to complete 4 tasks out of the twelve tasks attempted. User thirteen result for task seven is missing, and therefore the results above comprise of 154 responses in terms of task completion time.

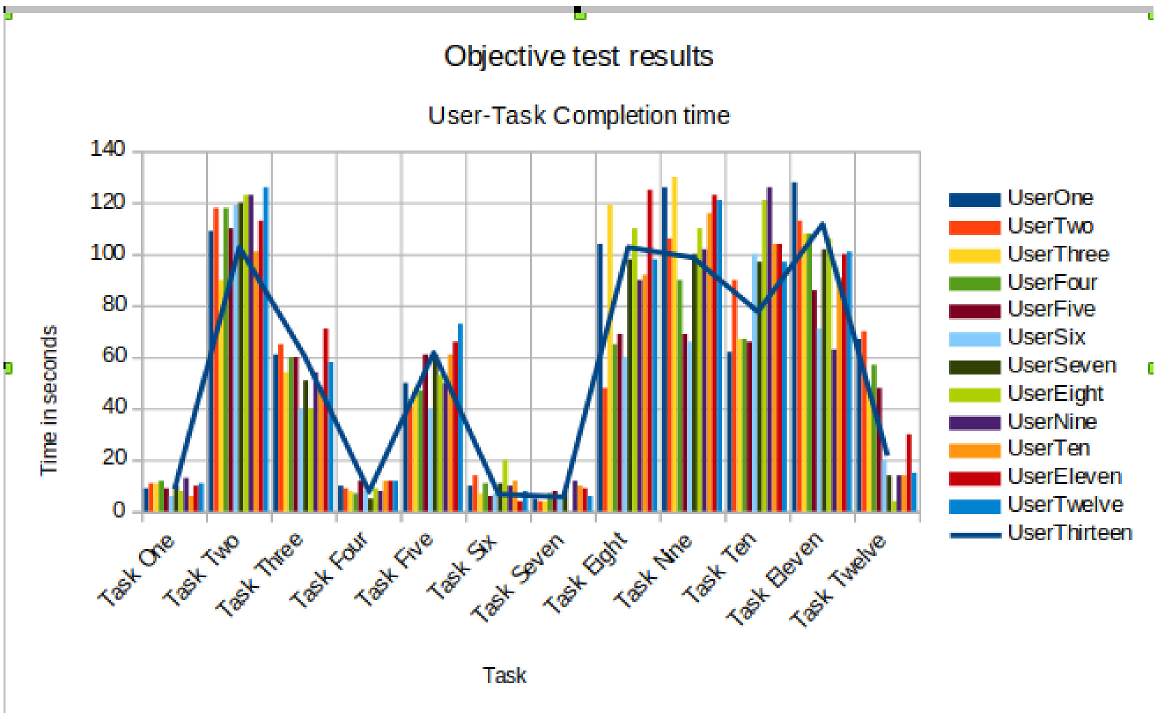

Fig:1.3 Chart showing the user-task completion

The bar chart above shows the distribution of user-task completion time for all the twelve task performed. The data for objective measures were collected during usability testing and the researcher summarized the data for each of the 24 objective metrics from the frame work as seen in the bar chart above. The results show that the completed task varied in the time taken by each respondent. The results below are the test results of usability evaluation which aimed at measuring the effectiveness, efficiency and user satisfaction of the prototype application.

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Effectiveness

$$Effectiveness = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}} \times 100\%$$

In this study, 13 users performed a task using the prototype on android smartphone technology. At the end of the test session, 10 users managed to achieve the goal of the task while the other 3 did not. From the above equation, the overall user effectiveness of the system therefore, was worked out as follows: Number of tasks completed successfully = 10 Total number of tasks undertaken = 12. Inserting the above values into the Effectiveness equation gives the effectiveness of 83.33%.

According to ISO-9241, Statistical error in tests with a small number of respondents is certainly high. However, even a small number of respondents are able to reveal a lot of user errors in a product which cause scenario completion failures. Therefore, as a rule, the optimum respondent number for product effectiveness test is 11-15. This number of respondents is enough to reveal 90-95% of all major user errors in the product, statistical error of the result calculation being about 10%, so the overall product Effectiveness can be determined with sufficient degree of confidence: The Effectiveness of a product is rated as awful (0-50%), bad (50-75%), normal (75-90%) and good (90-100%). therefore, for the objective test, the prototype application was rated as normal by the test respondents.

Efficiency

While efficiency can be measured as the task effectiveness per task time as follows, User Efficiency = Effectiveness/Task Time. The research used alternative measures of efficiency to achieve an optimal solution while measuring efficiency as time-based efficiency and relative efficiency.

Overall Relative Efficiency

The overall relative efficiency uses the ratio of the time taken by the users who successfully completed the task in relation to the total time taken by all users. The equation can thus be represented as follows: Although it may look intimidating, it is easier to understand if you apply numbers. =68.33%

Satisfaction:

According to ISO-9241 standard with the product is defined as “comfort and relevance of application”. In contrast to Efficacy and Productivity, where the user’s actions are observed and evaluated, Satisfaction aims at subjective thoughts of the user. Therefore, the objective test respondent also rated the application’s usability through ranking the usability checks. The usability checks for user satisfaction rating results show descriptive statistics with mean score for each measure is presented in the table below.

Table 5.1.2: Descriptive statistics summary for the objective test

Table 1.4 Descriptive Statistics for the objective test					
	N	Minimum	Maximum	Mean	Std. Deviation
Check for user interaction with the application	12	3	5	4.50	.674
check for availability of communication tools	12	3	5	3.92	.900
check for usage of gestures	10	2	5	3.20	.919
check for main menu presence	12	4	5	4.58	.515
check for scrolling	12	4	5	4.58	.515
check for heirachical menu	11	3	5	4.18	.751
check for navigation keys	12	3	5	4.67	.651
check for response to input	12	3	5	4.17	.835
check for audio instructions	10	1	4	2.30	.949

Check for time taken to load the application	12	4	5	4.58	.515
time for task completion	12	4	5	4.58	.515
Availability of Virtual keyboard	12	4	5	4.58	.515
Task related Clues/hints	12	2	5	3.67	.778
Availability of tutorials	10	2	4	2.70	.823
Help Icon	12	4	5	4.67	.492
Identify a link or icon usage	12	3	5	4.50	.674
check for suitability of language	12	3	5	4.33	.651
check for suitability of content	12	3	5	4.33	.778
check for alternative learning options	12	2	4	3.42	.669
check for assessment of result availability	11	2	4	3.00	.632
check for customization and personalization options	12	2	4	3.33	.651
check for short error messages	12	3	5	3.92	.515
check for user controls	12	3	5	4.17	.718
check for suitability of reading	12	3	5	4.25	.754
Valid N (listwise)	7		**AVERAGE**	**4.005**	**0.682**

The table above shows the descriptive statistics analysis result from the objective test presenting the mean and standard deviation. The average mean for all the system checks was 4.005 and the individual results were varying with a significant measure of 0.682. This shows even though the task could be related, they were independent of each other and the time or effort required for completing a given task does not affect another task and each task was measure independently. Using the means to calculate total satisfaction, a value of 80.0% is attained for satisfaction.

Sub-factor and Usability attribute performance measurement of the means

VI. Discussion

The study focused deeply into internal usability metrics according to ISO 9126 that are used for predicting the extent to which the mobile learning application prototyped in this study can be understood, learned, and operated, attractive and compliant with usability regulations and guidelines.

The results presented above were gotten from the objective test that aimed to test for the user levels of satisfaction and how these levels could impact the overall use of the application under study. The usability of the application was hence measured and individual scores of attributes of usability were analyzed. The results obtained from our study showed that interface designs well suited for mobility can highly improve the performance of learners and instructors while stationed or even on the move. Given cognitive load, the designs should be well suited for easy navigation and accommodate multiple input in form of voice, multimedia text or video.

The developed framework therefore, provides a comprehensive structure for evaluating the usability. Basically it presents the usability characteristics and the UI design criteria for mobile learning application in universities and higher learning institutions. The results also showed that the framework is not only useful for evaluating usability and comparison of different application but also helpful to uncover usability issues and highlight the UI design areas for suggested improvements. Thus it is evident from results that the framework proposed in this research is effective and reliable.

VII. Conclusion

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The concept of usability measurement ensures that the interactive designer understands the metrics that provide basic users with exceeding levels of usability by providing the users with the ability and tools to measure the quality of the intermediate deliverables provided by the mobile learning prototype in this study, and thus predict the quality of the final product to be implemented by the institution under study.

The system users to provide a measurement and correction mechanism to the designer in order to identify quality issues and, as a result, initiate corrective action as early in the development life cycle as possible in order to avoid, among other avoidable costs, operation and implementation issues. Thus the system has often received upgrades based on user demands

The usability metrics that successfully assess whether a product satisfies the demands of defined users in order to achieve stated goals with effectiveness, productivity, safety, and satisfaction in a specific context of usage, in this case, mobile learning. The current university platform is fairly effective and quite satisfactory to users

References:

1. Abran, A., J. W. Moore, P. Bourque, and R. Dupuis, eds. 2004. Guide to the software engineering body of knowledge. Los Alamitos, Calif.: IEEE Computer Society Press.
2. Alden, J. (2013). Accommodating Mobile Learning in College Programs. Journal of Asynchronous Learning Networks.
3. Ali, A., Ouda, A., & Capretz, L.F. (2012) “A conceptual framework for measuring the quality aspects of m-learning”, Bulletin of the IEEE Technical Committee on Learning Technology.
4. Hanson, K., & Shelton, B. E. (2008). Design and Development of Virtual Reality: Analysis of Challenges Faced by Educators. Educational Technology & Society
5. Hsu, Y. C., Ching, Y. H., & Snelson, C. (2014). Research Priorities in Mobile Learning: An International Delphi Study. Canadian Journal of Learning and Technology
6. Hussain, Azham, and Maria Kutar. "Usability metric Model for mobile phone application." PGNet, ISBN, 2009.
7. Introduction into Usability, Jakob Nielsen's Alertbox Retrieved April 10th, 2023. From the http://www.useit.com/alertbox/20030825.html.
8. ISO 9241: Ergonomics Requirements for Office Work with Visual Display Terminals (VDTs) International Standards Organization, Geneva (1997).
9. ISO/IEC, 13407. Human-Centred Design Processes for Interactive Systems. 1999: ISO/IEC 13407: 1999(E).
10. ISO/IEC, ISO/IEC 9126 in practice: what do we need to know? [Online] Available at: http://www.essi.upc.edu/~webgessi/publicacions/SMEF%2704-ISOQualityModels.pdf.
11. for handheld mobile device interface design.
12. Jung, H.-J. (2014). Ubiquitous Learning: Determinants Impacting Learners’ Satisfaction and Performance with Smartphones. Language Learning & Technology.
13. Karagiorgi, Y., & Symeou, L. (2005). Translating Constructivism into Instructional Design: Potential and Limitations. Educational Technology & Society,
14. Masters, K. (2004). Low-key m-learning: a realistic introduction of m-learning to developing.
15. Nassuora, A. B., (2013). Students Acceptance of Mobile Learning for Higher Education in Saudi Arabia, International Journal of Learning Management Systems, Natural Sciences Publishing Cor.
16. Uncertain Times
17. R. Harrison, D. Flood, and D. Duce. Usability of mobile applications: literature review and rationale for a new usability model. Journal of Interaction Science, 2013.
18. Robin Deegan. “A Classification of M-Learning Applications from a Usability Perspective”. Journal of the Research Center for Educational Technology (RCET) 16 Vol. 6, No. 1, Spring 2010
19. S. Wang and S. Dey, “Adaptive mobile cloud computing to enable rich mobile multimedia applications,” IEEE Transactions on Multimedia, 2013.
20. Tapanee Treeratanapon. “Design of the Usability Measurement Framework for Mobile Applications.” International Conference on Computer and Information Technology (ICCIT'2012) June 16-17, 2012, Bangkok
21. Vavoula, G., & Sharples, M. (2009). Meeting the challenges in evaluating mobile learning: A 3-level evaluation framework. International Journal of Mobile and Blended Learning,
22. Zhang, D. and Adipat, B. "Challenges, Methodologies, and Issues in the Usability Testing of Mobile Applications". International Journal of Human-Computer Interaction, 18, 3, 293 - 308, 2006.