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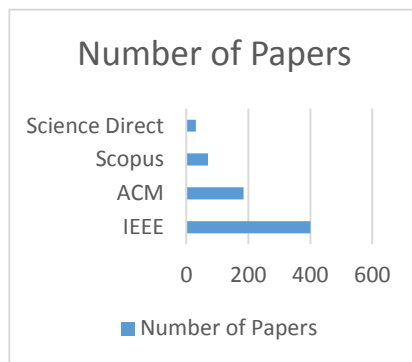# USABILITY EVALUATION METHOD FOR MOBILE LEARNING APPLICATION USING AGILE: A SYSTEMATIC REVIEW

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Graphical abstract

Abstract

The use of mobile phones for academic purpose has been on the rise in recent years. Most m-learning applications have been proved that they did not undergo usability evaluation while a few of the application underwent reliable usability evaluations. This paper reviews previous research that has been carried out to evaluate the usability of m-learning applications and how this approach could be integrated into the Agile development process in a bid to make a more effective and usable m-learning application. We focus on previous works that has been done in both, mobile application usability and integration of agile approaches for Usability evaluation. The incorporation of agile development processes and the usability evaluation of m-learning applications has produced a significant impact. This is seen as more m-learning applications are done in the sprints with the usability evaluation preceding it and following the development process which makes the applications more usable and user friendly.

Keywords: M-learning, usability evaluation, agile development process.

1.0 INTRODUCTION

With the rapid rise of mobile phone users in recent times, the use of mobile phone have been widely accepted with a projection that by year 2020, it would be the primary source of internet connection [1]. The use of mobile devices has transcended the routine use of calls and message, due to the enhanced ability of modern mobile phones to run applications, this has broadened the use and now it has the ability to support m-learning [2]. The use of mobile application for m-learning is gaining more grounds due to it pervasiveness and it ubiquitous nature which makes the learning process to be continuous regardless of time and space. [2].

A systematic review of usability evaluation for mobile learning application is important so as to know the current state of mobile application usability and how it has evolved over the years. This going to give insight about how mobile evaluation would aid in designing usable application for mobile phone users which would in turn lead to a high yield in the application review and improve users experience Mobile application markets are loaded with huge amounts of applications. This large numbers leaves users in a dilemma on which application to install that would give the maximal ease of use [3], this makes mobile applications with very low usability to reduce the user productivity and in-turn incur more cost for the application developer [4]. This shows the importance of usability of applications that are delivered to the users. M-learning applications are faced with different usability challenges [5].

Usability of mobile applications is important, this paper aims at reviewing previous literatures in identifying how usability evaluation can be carried out with agile development processes during application development. Due to the little availability of studies on usability evaluation of m-learning application using agile, a systematic mapping study was further done. This provides a wider overview for the research to be done and in doing this, the following research questions was obtained.

1. What are the current usability evaluation approaches for mobile learning applications
2. How is agile being integrated into mobile application usability evaluation

2.0 LITERATURE REVIEW

Mobile devices are improving rapidly and are becoming more available to people and this makes it open up new channels for learning [2]. The primary aim of a learning application or system is to avoid side distractions that affects the users so as to keep the learnt content fresh in the users minds and gives them an avenue to learn new things [6]. The primary challenge in an m-learning application is creating an interactive system that is easy to use without confusing the users. In this respect, the varying nature of mobile devices poses a big challenge in terms of usability [5] because the applications have to respond to external events which makes them more complex and have more usability problems   and thus makes it more important to evaluate mobile usability in real world scenarios   [3]. The usability problems of mobile applications can be identified through a series of approaches which includes task analysis, cognitive walkthroughs, heuristic evaluation, Goal Operator Method Selection rule (GOMS) analysis [7]. The usability issues being faced in mobile applications includes screen size which is due to the varying screen sizes of the mobile devices, the screen resolution, lack of physical accessories such as keyboard and mouse, hardware constraints, limited memory, bad user interface design and the information clustering on screen constitute usability challenges in application usage for learning [2], [5], [7]. Norman and Nielsen [8] equally highlighted usability issues on android phones which are related to visibility, feedback and presentation. In addition, Norman highlighted that an informative product or application should [9]:

- Be interactive with the ability to provide feedbacks
- Should have specific goals
- Should motivate and encourage using a continuous sense of challenges
- Provide suitable tools
- Avoid distractions ad nuisance factors that interrupts learning activities

All this serves as a challenge in an m-learning applications.

M-learning definition has evolved over the years. M-learning according to O'Malley is a type of learning which the student gains knowledge provided by mobile technologies [10]. While Crompton, 2013 explain it as "learning across multiple contexts, through social and content interactions, using personal electronic devices" [11]. It has aided people over the world to learn important things regardless of the barrier [12]. M-learning can be done to supports learning in two different way either where a user has a device apportioned to him. Those is visible in schools or where each user has his own device (BYOD) [2].

Research has shown that 73% of m-learning applications are native apps that stored on the user devices while 27% are web based apps. 40% of the total m-learning applications are game based. 57% of m-learning applications are only being evaluated for usability with 35% being evaluated using heuristics evaluation [2]. This shows the lack of usability for m-learning applications [5].

2.1   Usability of M-learning Applications

Wong et al. while evaluating the usability of learning applications considered a range of factors which included; the system feedback rate, user's like/dislike, error recovery consistency, cognitive load, internationalization, privacy, error prevention performance / efficiency, and on-line help [13]. Ardito et al. [14] equally analysed the usability evaluation of learning applications and they used the System Usability Evaluation (SUE) with which they highlighted four dimensions which learning applications must satisfy. This includes presentation, hypermediality, application proactivity and user activity. The presentation dimension which is concerned only with the aspects that are related to the visual design tools of the learning application, the hypermediality dimension which is an important aspect to the users (lecturers and students) due to the reason that it gives room because it allows for appropriate structuring of the materials which allows the user to select a personalized path for learning. Application proactivity considers the system ability to support user's activities. Errors in the system should be as low as possible, in the presence pf an error the system should be able to support and manage it. While the user activity dimension focuses on the rising need of the user and how the application copes with it.

Ardito et al. [6] classified usability issues into three broad categories which includes presentation with 80% of users considering as a usability issue, orientation had 95% of user's complaints and functionalities with the lowest usability issue of 65% of user complaints. This highlights that major usability issues stems from the presentation and orientation of the learning application. This is equally buttressed by the previous usability issues highlighted above such as the information display which is an orientation issue.

According to Cota et al. 2014, usability evaluation of m-learning applications should be based on two things which are the pedagogical usability and user interface design usability in a bid to improve their quality of user. The pedagogical usability is concerned

with the ease of usability in terms of contents of the education, it consists of five subdivisions. While the user interface design usability is important for the positive use and acceptability from the users. Thus it is concerned with the ease of use and remembrance by the user, it has six subdivisions. Usability is an important aspect to be considered in m-learning applications due to the problems related to mobile devices. [2].

Usability engineering is an area that gives room for the developers to know and to be able acknowledge and address the usability needs and demands of their users. Usability evaluation plays an important role in application development [4]. Usability has various definition from different authors. Usability according to IEEE " is the ease with which a user can operate, prepare inputs for, and interpret outputs of a system or component" [15]. In a similar view, Rubin and Chisnell explains usability in respect to the degree that the users were able to make use of the product in order to achieve what it is meant for in an efficient and effective way [16]. In another different sphere, Nielsen said usability also means the ways to improve the use of an application during design process [17].

Mobile usability evaluation is an emerging field in the usability engineering domain. Usability evaluation is important in mobile application development, but still in its infancy [3]. Nielsen [17] did more for mobile sites evaluation where he showed that the usability of a mobile device includes both the social and practical aspects. Alsumait and Al-Osaimi [18] further buttressed that for a learning application to perform optimally in the market, it must be analysed in terms of it usability for the users in terms of educational benefits and its interactive ability. This is important because e-learning and m-learning applications should satisfy some HCI factors like effectiveness, satisfaction of interfaces and effectiveness. It should equally satisfy the pedagogy of learning and educational domains [18].

Using agile for mobile application evaluation does not fits in to the modern usability evaluation approaches [19], [20] but Kane and Da Silva et al. suggested that by incorporating usability evaluation approaches as part of agile development methodology can enhance the usability of the system because agile encourages iterative testing and thus has the ability to be integrated with usability evaluation [19], [21]. On integrating agile methodology with User Centered Design (UCD), it improves application usability and this is more pronounced since most developers prefers agile development than traditional development approaches [22].

3.0 METHODOLOGY

Considering the discussion above, the importance of usability evaluation in mobile applications cannot be over-emphasized. In conducting this study, a systematic literature review was done. A systematic literature review can be seen as a way for identifying, studying, evaluate and interpret available research that is particular to a domain or a topic area of interest [23]. This can be undertaken so as to summarize the current and past literatures in respect to a term or keyword, and to identify gaps that exists in the current research state in order to raise suggestion that would give rise for further research and to provide a new framework that guides new research activities.

The formulated research questions guided the search terms and keywords that was used in getting the previous studies. This study used four primary source of data which were:

- IEEExplore Digital Library
- ACM digital library
- Scopus
- Science Direct

Other studies were equally gotten from Google scholar, but they were very few.

The key words used in searching from the above database was adapted from [2] which includes: ("mobile learning" OR "m-learning") AND "usability", this search query was modified with agile and evaluation added to it which made it to be (("mobile learning" or "m-learning") AND ("agile" and "Usability" and "evaluation").

4.0 RESULTS

There were 685 papers returned by the query from the databases that was searched as stated in figure 1. On the overall, 45 papers were found useful with 35 being studied. The usability of the papers was chosen based on the relevancy of the paper on the subject being studied in respect to usability evaluation using agile for m-learning applications. Most of the papers returned discussed primarily in usability evaluation of applications using agile with little respect to mobile. This study further reviewed the literature for the best practices in fusing usability and agile together and came up with four models from the literatures reviewed.
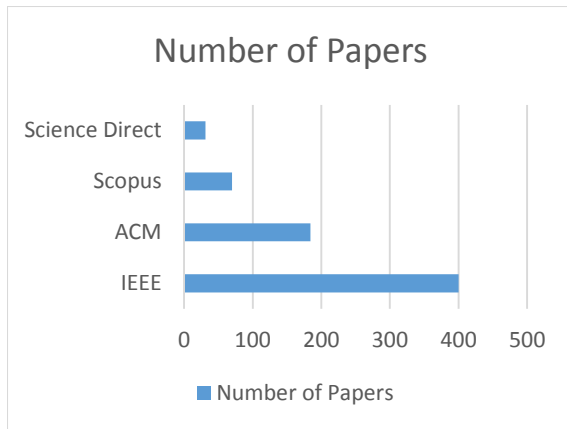
Figure 1 Paper distribution graph

5.0 DISCUSSION

It was seen that usability testing when done correctly has the potential of identifying major issues with 6-8 test users sufficient in identify major usability issues [24]. This is based on the user's feedback on the interaction with application. Usability engineering starts at the conceptual phase which includes field studies and deep enquiries on the functionality of the product [20]. Nielsen showed that studies done in the post release stage shows a lot of usability issues that may result in dire consequences [25], in contrast, kaikkonen et al. showed that the field studies is not the ideal solution for usability evaluation on mobile applications because it consumes twice the effort and doing pilot tests is important so as to ensure that usability testers highlights major usability issues [26].

Performing Usability test at the tail end of the development leaves room for the risk of insufficient period and resources to address the usability issues while conducting test on simulators reduces the test validity and gives room for usability defects [4]. The short time frame that exist in development iteration in agile makes it difficult to perform an ongoing usability evaluation and functionality testing. [27].

Thus it is important in seeing how to incorporate usability into agile development processes [28]. Agile methods begin implementation at the early stages with a shorter requirement engineering stage and less documentation. The code implementation is done in short increment and iteration usually called sprints, with customer using the releases after each development cycle [18]. Due to the reason that Agile doesn't qualify as a user centred design, In integrating usability with agile, Constantine advocates a process that begins with interface design followed by the agile development process [29], this is challenged because the interface usability design bottlenecks the overall development process and this violates the basic principle that agile stands for [30].

Memmel et al. [31] made a framework called a CRoss-discipline User Interface design and Software Engineering (CRUISER) for the integration of agile for usability evaluation as shown in figure 2. This lifecycle integrates both SE and HCI with agile development process. They used an XP and showed that the result was implemented using scenarios and prototype as the basic foundation in driving a user centered process that involves high co-ordination and participation between the users and at the same time, the project stakeholders.
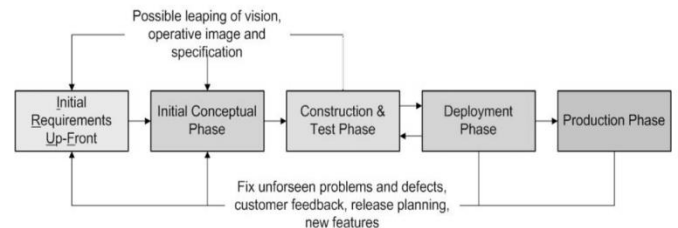

Figure 2 CRUISER framework [31]

At the initial stage, it begins with the initial requirement up-front. This stage makes use of agile principles integrated with HCI and authoritive design in an attempt of having the usability heuristics up-fronts. This is done by using use cases, user stories etc.

Due to the reason that agile do not take the UI in details, light weight style guides which is shorter and contains more UI patterns for evaluation. Altogether the use of agile with HCI enhances the usability of the applications. This is implemented through the use of early prototypes, first designs which are later refined in the later stages. The usability of the application is further enhanced with iteration between all stages in the development of process from the initial requirement to the production which is an agile feature. [31].

Sy [32], while working on the integration of agile with usability, he argued that because agile places focus on new features at a particular time, the usability evaluation of the whole system needs not to be done at the same time which then gives room for laying focus on the important designs to be done at a time. They conduct usability evaluation of the implemented design with close interactions with the developers in an order not to deviate from the stated design. The framework are shown in Figure 3 below. Due to the reason that the developers are working on a feature at a time while the interaction designer work on the subset design. This means the features receive usability evaluation upfront before developer implementation.

The strength of this approach is its usability evaluation, which is done through the design iteration; where design failures are caught early which gives room for
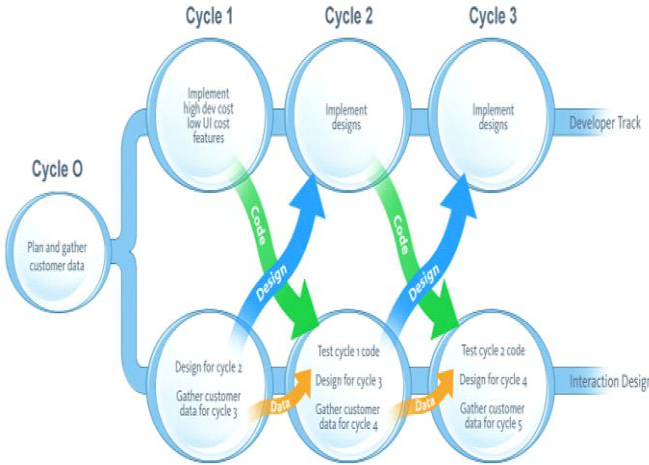
they suggested and placed much importance on the use of low fidelity prototypes that have an aim to improve the overall design.

This framework operates between the usability evaluation of previously designed application which is used to modify the previous design and incorporate it into the new release.
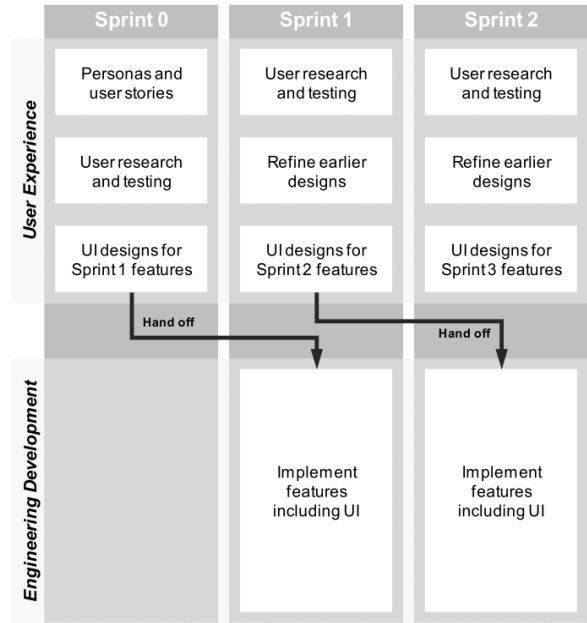
6.0 CONCLUSION

Figure 3 Sy Framework [32]

early design changes which incorporate design fixes, thus the prototypes are being checked before the actual coding begins. In a bid for full integration between user designer and developers due to implementation time, there existed two tracks for full implementation which consisted of the designer track and the developer track. This approach places stress on the granularity, the reporting and equally the adaptation to the timing that was used for the agile usability investigation. They found that the approach produced better results.

Najafi and Toyoshiba [33] explained integrating User Experience Design (UED) into agile development in an effort to enhance the usability of the designed product trough involving the User Experience Team that helps in assisting to prioritize the features of the product and which in turn iteratively enhance the design and improve usability, the integration of the team according to them requires the optimum support and collaboration with all cross functional team members.

This framework as shown in Figure 4, depicts the role of the user experience team in the application development by being saddled with the primary usability evaluations before being forwarded to the development team. At the initial sprint, the development team with the user experience team goes through the designs and requirements together, the errors found in the implementation are corrected in the subsequent sprints.

Equally Da Silva et al. came up with a framework for integrating both process for the usability evaluation of mobile applications [21]. Here they placed focus on the application design with the usability. In designing,

Figure 4 Development Framework [33]

In conclusion, this study discusses about the current approaches for usability evaluation of mobile applications. In solving the first research question, it could be seen that mobile usability testing is done using different approaches, but in heuristic approach which is used alongside agile, it is done in two approaches which includes the field studies or using user experienced designers in evaluating usability of mobile applications. These two approaches when implemented in agile, it can be achieved by having more iterations to the agile development cycle and with more User Experienced designers specialists, to verify the usability in an iteration before developing it in the next iteration, with this approach, usability evaluation and agile development processes are compatible and can work together.

This serves as the bedrock of all agile methodology and can be seen from the discussed frameworks above. Thus, the usability evaluation of mobile applications using agile is best done in sprints with user experienced designers.

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