A Mobile Usability Evaluation of a Pregnancy App

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***Abstract*—The upsurge in the use of mobile devices worldwide has led to an increasing number of mobile apps developed and available in the market today. This makes the mobile usability of these apps an important issue to consider. This study evaluates the mobile usability of Amila Pregnancy app, a mobile assistive app for pregnant women and expectant mothers. The paper reports on the outcome of a mobile usability evaluation for Amila Pregnancy app. In the study, five usability qualities were evaluated in line with the Jakob Nielsen's usability principles, these are, inter alia: effectiveness, efficiency, learnability, memorability and satisfaction. The outcome shows the trouble mobile users had in understanding displayed icon, locating the information provided, re-finding it and in navigating through the mobile app. In conclusion, the study recommends that the main menu of the app be further improved upon to boost its usability.**

***Index Terms*—Amila Pregnancy App; Mobile Usability.**

I. INTRODUCTION

Electronic devices such as mobile phones, tablets, wearables, mobile TVs, etc., have become very indispensable in our everyday life in today's technology-driven world. These devices shape and impact the way people think, and live, whether they are used for official or personal purposes. The swift advances of Internet and communication technologies (ICTs) in the last twenty years has tremendously transformed people's lifestyles the world over. Equal access opportunity is available for the use of mobile devices for people living in both cities and villages. A study done by the Malaysia Digital Association found that in 2016, 47% of Malaysians accessed websites from their mobile phones and spent an average of 5.1 hours a day on the Internet [1]. Handhelds such as smartphones and tablets have become something very essential in all areas of life. With just a simple touch of the keypad, users with high-performance mobile devices and with ubiquitous access to the Internet can perform a variety of tasks, from accessing online information to staying connected to people across the globe.

With mobile devices becoming more and more pervasive, mobile applications are also increasing in availability and popularity [2] and they present exciting new opportunities especially in the improvement of health and wellness. Given this trend, the market for healthcare apps is speedily rising. To be precise, more than 165,000 health apps are available in major app stores [3]. Many people use smartphones as their main means of accessing healthcare information and as helpful apparatuses for healthcare management. This is for the reason that mobile apps have the prospective to support and manage their health better [4]. With apps now becoming an essential source of information and a self-monitoring apparatus for offering assistive reassurance to pregnant women, there are now many pregnancies and parenting apps available in the market for both pregnancy and parenting [5].

Mobile pregnancy apps have become a new way of providing maternity information that are readily accessible, literally at the touch of a button, with little or no cost and at any time and any place. Nevertheless, the foremost concern is about the quality of these developed and deployed apps. Consequently, there is the need to monitor the quality of information provided by mobile pregnancy apps. Identifying women's needs during the prenatal period is a must. This has necessitated the need for this study, and accordingly, in this study, an attempt is made to evaluate the mobile usability of Amila Pregnancy app, a mobile pregnancy app, to determine the quality of its mobile experience.

Amila Pregnancy is a mobile app that has been constructed for pregnant and expectant mothers. It is a very helpful and useful app for the weekly monitoring of their pregnancy. This app has been used all over the globe. It has more than 500 thousand downloads and an average rating of 4.81. Thus the evaluation of the users' mobile experience of the app is worth the effort undertaking. Consequently, the purpose of this usability study is to evaluate the ease of use of this mobile app's interface [6][7][8][9], to ascertain the perceptions of pregnant women and their spouses about the usability of the app. In clear terms, the study seeks to measure the perceived effectiveness, efficiency learnability, memorability and satisfaction of the app in order to capture the app's perceived mobile usability [10-13].

II. LITERATURE REVIEW

One of the main elements that determine the success of the development and utility of interactive mobile applications is usability [14-15][16]. Conversely, though many researchers have been conducting studies on health-related mobile apps, many of these studies lack depth [17]. Furthermore, there are few studies carried out to assess the mobile usability of apps. Usability constraints and issues can be overcome by design guidance, best practices, usability testing and heuristics reviews. Brown et al. used group session [17] in assessing the mobile usability of apps in health technology [18][19]. They used group session to explore adolescents' use of mobile technology to discover their information need in health technology. Besides, a similar technique was used in locating the appropriateness and usefulness of mobile apps in the assessment of mobile technology in health-related areas.

With a focus on the mobile usability of apps for the monitoring of the elderly, Panou et al., [20] assessed the prototype of a mobile health app, called the Guardian Angel to find out the prospect for its deployment in the health market. They proposed some enhancements to improve the

usability rating of the app, some of which include: decreasing the complexity and amount of information in the mobile apps' interface and the provision of additional help menu for virtual assistance. Furthermore, Isakovic et al. [21] examined a diabetes monitoring app (DeSA) that was constructed for the EU project and tested in a hospital environment in order to guarantee the mobile app's suitability for use. They found that special care needs to be taken when developing mobile apps in the health area particularly those meant for the elderly [21]. Another area that they emphasized was the handling of exceptions and faults. In mobile health apps, this is very imperative as medical decisions that are made on faulty data have great effect on patients and can have dire and grave consequences.

Hussain et al. posited that the rise in the number of mobile applications makes the usability evaluation of web-based applications for smart mobile devices crucial and significant [22]. Their study concentrated on the usability of a web-based health awareness portal for smartphones using ISO 9241-11 standard. They used lab-based usability testing, and collected metrics like: task time, task completion rates and task errors. The reason why these performance metrics were collected was to measure the effectiveness and efficiency of the portal. Effectiveness was measured using task completion rate and task error, while efficiency was measured using task time. System satisfaction, on the other hand, was measured subjectively using task ease and SUS questionnaire. In addition, Zhang et al. proposed usability metrics for health app assessment. They provided strategies to get the perceptions of both healthcare consumers and providers [23]. They also suggested an extended metrics and a new classification scheme for research on mobile health app to enhance their development. Additionally, they provided guidance for the design and implementation of mobile health apps as well as the understanding of the usefulness and usability of such apps. Zhang et al. [23] suggested a classification scheme on the challenges of mobile health apps and the strategies for appropriate development.

Harrison et al. [24] in their work, reviewed mobile usability models and confirmed that the usability of mobile apps is mainly measured in three dimensions, viz.: effectiveness, efficiency and satisfaction. They proposed the PACMAD usability model that was designed to complement the limitations existing in usability models for mobile devices. PACMAD was drawn from different usability models in order to create a more comprehensive and robust model. The authors also did a literature review to compile a collection of studies that assessed mobile apps and then evaluated the studies using their model.

Moreover, O'Malley et al. in their research paper tested the effectiveness, efficiency, and user satisfaction of Reactivate mobile app for adolescent obesity. Ten adolescents completed 8 tasks in order to test the effectiveness of the app [25]. A research assistant timed the users while they are completing each task in order to test the relative user efficiency of the app (time-on-task). For the user satisfaction towards the mobile apps, the participants were required to complete the SUMI questionnaire that measured 5 characteristics of user satisfaction, viz.: efficiency, effectiveness, helpfulness, controllability, and learnability. Besides, Ismail et al. focused on the usability issues in mobile applications in education, health and tourism sectors. They found the following issues as related to usability: ease-of-use, convenience, learnability, user satisfaction, task-technology fit, accessibility, coverage, accuracy, orientation clues, conciseness, and culture [26]. Accordingly, they concluded that the core issues across these education, health and tourism sectors are flexibility, visibility, satisfaction, consistency, and aesthetics [27][28]. On the other hand, they found out that the issues are various, but similar terms such as user friendly and user control and freedom have synonymous meaning.

Likewise, Anderson et al., explored on how health consumers use mobile apps for health monitoring, and their perceived profits from use of such health apps. They made suggestions for the enhancement of mobile health apps [3]. They used interview for the collection of the needed data from the selected consumers in the selected area. They also used semi-structured interview guide that composed of questions from the Technology Acceptance Model, Health Information Technology Acceptance Model, and Mobile Application Rating Scale. The transcript was analyzed using interview deductive thematic analysis. Implicit and explicit responses not aligned were analyzed inductively. The outcome gotten from the deductive and inductive thematic analysis reduced the data to four principal themes: engagement in the use of the app, technical functionality of the app, ease of use and design features, and management of consumers' data. They strongly believed that the semi-structured interview identified the utilization, benefits and challenges of health monitoring apps. Hence, understanding the range of consumer experiences and expectations can impact on the design of health apps.

Chatzipavlou et al. opined that mobile health apps supported by smartphones play vital role in healthcare and advance both the quality of medical services and the safety of the patients [29]. They defined the role of developers in the mobile health apps' market, the obstacles they face and also, the influence of their work in the mobile healthcare sphere. They proposed a guideline with all the developers' requirements for the development of mobile health apps. Moreover, they utilized the following methods: a Boolean search strategy that is used in academic libraries (PubMed, IEEE Xplore, JMIR, The Cochrane Library) and search engines as well (Google and Google Scholar), to find out the developers' viewpoint. They found from their research several demands that developers have to meet and the acknowledgement of the prevailing role that developers have to play in mobile health apps' processes. They maintained that developers should define the purpose of each app to gain the confidence of users and to dominate the market.

III. METHODS

A. Design

The usability test processes used in the conduct of the test session included the think-aloud method. In order to gain insights into participants' cognitive processes and attitudes towards the Amila Pregnancy mobile app, this protocol was utilized. The protocol involved asking participants to freely verbalize their thoughts and feelings whilst engaging and interacting with the app, additionally, background interviews, pre-test (pilot test), actual test, mobile application responses and post-test questionnaires were employed. Data collected during the evaluation process were analyzed using descriptive statistics, that is, mean and percentages.

B. Test Environment

1) Devices

The following devices were used for the test: Smartphones (Xiomi Redmi Note 3 and Samsung J3), Camera (Canon PC1737, and Nikon J1), Notebook Dell Inspiron 15 with Intel Core i5 and Tripod.

2) Software And Tools

The software and tools used during test session include: mobile operating systems such as Android Version 6.0.1, Amila Pregnancy mobile application, DU Recorder for screen recording and online questionnaire using Google Docs.

3) Test Location

The tests were conducted in a testing room at the Pusat ICT, Universiti Malaysia Perlis, as well as at the Health and Beauty Shop at Tesco Extra Sg Dua, Pulau Pinang. These two locations were chosen because the evaluator was very familiar with them and no booking and rental were needed. The testing room was equipped with air conditioner, chairs and a desk. Figure 1 shows pictures of the locations that were set up for the usability test.

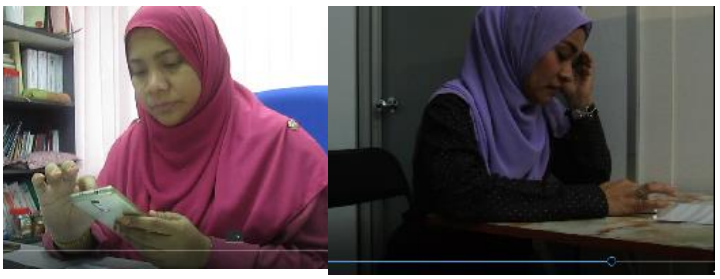
C. Strategies for the Usability Test

1) Procedure

Informed consent was gotten from all participants before the test session began. The test began with the evaluator greeting and welcoming the participants. The test session was based on an orientation script that was prepared earlier. After the participants understand what they were to do, they signed a nondisclosure and recording consent document. The evaluator explained the reason why video recording was to be used and maintained that it was for the capturing of the participants' thinking aloud. Thinking aloud was elucidated to the participants while the evaluator delivered response to questions asked and informed the participants where to begin. The participants completed a brief background questionnaire with the following fields: age, weeks of pregnancy, education, etc. After that, the evaluator passed round the tasks one by one, and then the participants read the task and began to work on the tasks while thinking aloud. The evaluator, while observing, takes note of participants' behaviors, comment, and eye tracking. The session continued until all the tasks were performed by the participants. If any participant could not do the task given, she/he may be asked to pass on to another task until the session is ended. At the end of the test, the evaluator asked the participants to respond to the post-test questionnaire provided on the desk. On the other hand, the evaluator also provides a link of the same questionnaire to the participants via the WhatsApp app. At the end of the test session, the evaluator appreciated the participants with some souvenir and gifts to compensate for their time and effort and accompanied them out from the testing venue. He then afterwards reset the test tools, and materials and repeats the steps until all the participants available for the test have all taken their turn in the test. Figure 1 indicates the testing tools viz.: a) is the testing room at Pusat ICT, UniMAP and b) is the testing room at Health and Beauty Shop, Tesco Extra Sg Dua, Pulau Pinang. Figure 2 displays the picture of participants when testing is going on at the testing room.

(a) (b)

Figure 1. Picture of testing room and the equipment used during testing session.



(a) (b)

Figure 2. Picture of participants when testing is going on at both testing rooms.

2) Metric

Several metrics [30-31] were collected during the usability test session. Data from the test metrics collected were used to measure the actual use of Amila Pregnancy app while identifying the problems encountered [32]. The metrics collected include inter alia:

Task completion: The participants were required to complete each task given. The task is considered completed if the participants found the answer for the task goals, that is, was able to achieve the given goal for the given task [33].

Errors: Two type of error were discovered by participants, namely, critical and non-critical errors. Critical errors occur when the participants felt that they have already fulfilled the task given, but they might not be aware that the goal is incorrect or incomplete [34]. Non-critical errors are errors that are recovered from by the participants and do not lead to the participant's inability to successfully complete the task (the participant may have used a different pathway to complete a task) [34]. In addition, an error free rate is recorded for participants that completed their given task without failing.

Time taken on task: This is the duration that the participants took to complete the tasks given. Efficiency is measured in terms of task time. The time taken to complete a task can then be computed by simply subtracting the start time from the end time as shown in the equation below:

$$Task\ Time = End\ Time - Start\ Time \quad (1)$$

Recommendations and feedback: At the end of the test session, the participants were asked to subjectively evaluate the application through an online questionnaire and emoji card. The purpose of the emoji card was to measure the participants' satisfaction on the use of the app. Emoji card feedback had three choices: happy emoji was for good feedback, neutral emoji was for moderate feedback and unhappy emoji was for bad feedback.

3) Usability Test Plan

There were five task plans completed by the participants during the test session. First task was to view baby development information on weekly basis, the second task was added current weight / your wife current weight, the third task was to add a date for your next appointment with your doctor, the next task showed the listing of notes and view any notes and the last task was add and monitor your baby kick progress. All tasks were video-recorded, and the screen of the smartphone was screen-recorded to document which sections of the app participants were using during the test session.

4) Data Analysis

The data were analyzed thematically using Jakob Nielsen's five (5) usability principles. The analysis of data set was generated automatically using Google Docs and Microsoft Excel and other data such as observation data were analyzed and compared using tables.

D. Participants

The participants included pregnant women and their husbands. These participants were chosen because of their experience in pregnancy life. A selection question was used to recruit participants. The questionnaire contained the following questions: "Are you pregnant?", "Do you have some time for a mobile application experience?", "Would you mind if your husband joins too?" After the agreement from both parties (i.e., the participants and the evaluator), 15 participants were selected to participate in the usability test evaluation for Amila pregnancy mobile application [28]. The usability test on the application was visualized by eye tracking; so that the unconscious cognitive behavior can be spotted and captured. Eye tracking and monitoring bring more benefits such as the experience of observing how the participants interacted with the mobile application and listening to their opinion from their point of view. This kind of observation generates valuable data. The participants were grouped into two main categories: expert and novice users. Ten (10) expert participants had experience with the use of smartphones with Android OS app related to pregnancy but were not familiar with Amila Pregnancy apps. The other 5 participants had experience in the use of smartphones with Android OS, but do not have experience in apps related to pregnancy and also were not familiar with Amila Pregnancy app.

IV. RESULT

A. Results from Questionnaire Analysis

From the questionnaire, the demographic information about the 15 participants was captured. Out of the 15 participants, 67% were female and 33% were male. Among them, 60% had their age ranged 30-39, 13% had their age ranged 40-49 and 27% had their age range 18-29. With regard to participants' occupation, 55.3% of them were working in the government sector, 33.3% in the private sector and the rest were full-time housewives (13.3%). In terms of their education and qualification, 73% had college/university degrees, and 27% had high school certificates. Most of their community type was suburban (40%), those from rural type and urban type communities were 33% and 27% respectively.

The post-test questionnaire was divided into 5 parts based on 5 usability component: Part A - Satisfaction: subjectively pleasing, Part B - Memorability: easy to remember, Part C - Learnability: easy to learn, Part D - Efficiency: efficient to use and Part E – Few Error. Table 1 shows the summary of overall post-task questionnaires using mean and percent of agreement by the participants.

Table 1
Overall Post-Task Questionnaires

Usability Metrics Using Nielsen's Principles	Mean	Percentage
Satisfaction: subjectively pleasing	3.25	65.33%
Memorability: easy to remember	3.84	76.66%
Learnability: easy to learn	3.78	73.33%
Efficiency: efficient to use	3.86	77.14%
Few Error: easy to recover from errors	3.34	66.66%

*Mean & Percent Agree (%) for the combined responses for "somewhat agree", "agree" & "strongly agree"

From the result presented in Table 1, most of the participants (77.14%) agreed (i.e., somewhat agreed, agreed or strongly agreed) that Amila Pregnancy mobile app was efficient to use while 73.33% of them agreed that the app was also easy to learn. Over half of the participants 66.66% agreed that on Amila Pregnancy mobile app, it was easy to recover from mistakes. Even though participants' average agreement rating was 3.25, 65.33% were satisfied on the usage of Amila Pregnancy mobile app. A large number of participants perceived that it is easy to remember the use of the app (76.66%) over time.

B. Results from Observation

Task Completion Success Rate by Individual Participants: Out of the 15 participants, 11 (73.33%) successfully completed Task 5 (Add and monitor your baby kick progress). Ten (66.66%) completed Task 2 (Add current weight / your wife current weight) and Task 3 (Add a date for your next appointment with your doctor). Approximately half (46.66%) of the participants (i.e., 7 out of 15 were able to complete Task 1 (View baby development info on weekly basis.) and only 33.33% (i.e., 5 participants) were able to complete Task 4 (Show the listing of notes and view any notes.). From this result, it can be concluded that after some time spent on using this mobile app, users became more familiar with the mobile app compared to their first attempts which made Task 5 (Add and monitor your baby kick progress) to have the highest success rate.

Task Completion Success Rate by Groups of Participants: Only 25% of novice participants successfully completed Task 1 (View baby development info on weekly basis), Task 2 (Add current weight / your wife current weight) and Task 3 (Add a date for your next appointment with your doctor). None of them (0%) successfully complete Task 4 (Show the listing of notes and view any notes) and Task 5 (Add and monitor your baby kick progress). Nonetheless, all expert participants successfully completed Task 5 (Add and monitor your baby kick progress). Also, 81.81% of them successfully completed Task 2 (Add current weight / your wife current weight) and Task 3 (Add a date for your next appointment with your doctor). Six of eleven expert participants successfully completed Task 1 (View baby development info on weekly basis) (54.54%). However, only 5 out of 11 expert participants successfully completed Task 4 (Show the listing of notes and view any notes). It can be concluded that based on experience, experts are more likely to identify the task given. Novice users, in contrast, were somehow in the process

of mastering given tasks. In essence, it implies that experience counts.

Time on Task: Task 2 required participants to add current weight and took the longest time to complete (mean = 63 seconds). Task 1 that required participants to view baby development info on weekly basis took the shortest time to complete (mean = 42 seconds). However, most completion times were less than 57 seconds (less than 1 minute). For the standard deviation of each task, Task 1 (View baby development info on weekly basis) was about 26 seconds, while Task 2 (Add current weight / your wife current weight) was about 28 seconds. For Task 3 (Add a date for your next appointment with your doctor), Task 4 (Show the listing of notes and view any notes.) and Task 5 (Add and monitor your baby kick progress) were 27, 49, 23 seconds respectively.

Task Observations concerning each Participant's Actions on Task: From the observation and the video recordings made, Task 2 has a lot of expressions and reaction from participants. And this shows that Task 2 appears to be the most difficult task to complete compared to the other tasks.

Overall Rating on Amila Pregnancy Mobile App using Emoji: During the post-test interview session, every participants were asked to rate the mobile Amila Pregnancy app using emoji card. The emoji card captures their overall perception about the mobile app. By using emoji card, most of the participant (73.33%) expressed good feeling about the app. About 13.33% of the participants chose moderate and sad feelings about the app respectively. Table 2 reports the summary of the overall rating on the mobile Amila Pregnancy App using Emoji.

Table 2
Rating of Amila pregnancy mobile app using Emoji

Emoji	No. of Participant	Percentage
Good	11	73.33%
Neutral	2	13.33%
Bad	2	13.33%
Total	15	100 %

V. DISCUSSION

This study makes available a comprehensive understanding about participants' mobile experiences with Amila Pregnancy app. The results of this study for Task 1 which required participants to find baby development icon and view the baby information submit that the mobile Amila Pregnancy app need to be improved on. The current baby development icon needs to be changed and replaced with a bigger and bolder icon because the icon on baby development information was not clearly seen by users and was hard to locate by first timer users. The comments from participants signified that a suitable size of baby development icon be provided so that it can be easier to find. Task 2 which required participants to find weight tracker icon and try to add their current weight and Task 3 which required participants to find calendar icon and try to add their note or appointment recommend that the mobile Amila Pregnancy app need to be improved upon by changing the position of the buttons and putting them on the main menu of the app. Most participants commented that the list of menu provided for calendar was hard to locate. Moreover, Task 4 which required participants to show list of notes added on calendar and Task 5 which required participants to find Baby Kick button to manage the kick progress signify that the position of the list buttons need to be changed and labeled so that the users can easily locate it. The findings of this study overall; reveal that the mobile app needs a deeper and insightful study on the behavior of pregnant women in their daily routine. It is consequently needful that the existing functionality in the app be enhanced so that the application's interface can be made more usable in order to successfully attract the target group to use the application and for the app to sustain loyalty of its users.

VI. CONCLUSION

This study contributes to a better understanding of pregnant women's perception about the mobile Amila Pregnancy app that supports the daily routine of pregnant women. Usability testing of this kind of app is relatively new [35]. More so, it seems that this mobile app can be a suitable medium to offer expert advice and deliver enjoyable and comfortable feel to pregnant women during pregnancy [36]. Pregnant women place a high value on the information and support they obtain from and share using online sources and apps [19]. From the usability testing session, it can be concluded that data collected were from what the users do and act on, because of their attempts on the task scenarios. Using the right method, the goals and purposes led to the success of this study [20]. The study results indicate that most of the participants love the mobile Amila Pregnancy app and some of them took the initiative to install the app on their mobile devices. They found the app very subjectively pleasing, easy to remember, easy to learn, efficient to use and prune to few errors. Having a good menu button to access the Amila features is a key to a new enhancement and implementing the recommendations will guarantee a continued user-centred mobile apps. This study reveals that the mobile Amila Pregnancy app is acceptable, usable and useful to its target population. It offered users an enriching mobile experience.

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