Usability and Effectiveness of Mobile Learning Course Content Application as a Revision Tool

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Abstract: The use of mobile phone technologies in the education sector is getting more attention nowadays. This is due to the advancement of technologies equipped in majority of the mobile phones which makes the devices become more capable of supporting the learning and teaching activities. Mobile learning (m-learning) is a learning tool which can be run on mobile devices. It can be considered as an enhancement to the electronic learning (e-learning). M-learning overcomes several limitations of e-learning especially in term of mobility. It provides more independent way of learning whereby learners can use the application to do the learning activities at anytime and any place. However, as with other learning and teaching applications, applications to be developed for mobile learning must also be developed based on certain learning theories and guidelines in order for them to be effective as well as usable. Therefore, in this paper, the development process of a mobile learning course content application called Mobile System Analysis and Design (MOSAD) as a revision tool will be shared and its testing’s conduct and results will also be presented and discussed. MOSAD was developed with the content of a topic from the System Analysis and Design (SAD) course conducted at Universiti Teknologi PETRONAS (UTP). A heuristic test involving 5 experts in the area of Human Computer Interaction (HCI) were conducted after the first version of MOSAD was completed to strengthen its functionality and usability, followed by a Post Test Quasi Experimental Design which was conducted to 116 UTP second year students who took the SAD course to test the effectiveness and usability of MOSAD after it was revised. As a result from the post test, the students who had used MOSAD (66 out of the 116 students) as their revision tool for answering ten quiz questions obtained a mean score of 7.7576 as compared to 5.160 obtained by the other group of students (50 out of the 116 students) who used traditional methods of revision. Besides, usability test which tested on consistency, learnability, flexibility, minimal action and minimal memory load of MOSAD gave results above 3.5 for each metric based on the rating of 1 to 5. Thus, both results indicate that MOSAD is effective and usable as a revision tool for the higher education students.

Key words: Mobile learning, electronic learning, heuristic, post test quasi experimental design, usability.

1. Introduction

Developing learning applications for usage on mobile devices, in particular the mobile phones, has become popular nowadays. This is due to the many advantages which are offered by the mobile phone technologies. The advantages include removing the limitations of times and places in performing learning activities [1], reducing the formality in learning, which some research have identified to be the reason for learners to be passive in getting knowledge [2] and many more. The integration of the mobile phones technologies and learning activities increase students’ interest during the learning process as it provides easier ways of performing the learning activities such as getting learning materials, doing online quizzes, doing discussions and others. In addition, some studies have shown that by adopting suitable learning theories into computer-based learning applications, learners will be able to learn in a more effective way [3-4]. Similar to other non-mobile learning applications, implementing some learning theories when developing the content of the applications as well as their interactivity will make
the learning process to be more effective. As for mobile learning applications, learning theories that could be implemented include the cognitive, humanism and sensory stimulation learning theories.

Mobile learning applications, like other computer-based applications can be developed for many different purposes. One of them would be for assisting learners in revising their lesson. According to Encarta World English Dictionary [5], revision is a study that involves looking at notes and/or other course materials in preparation for a test, assessment or examination. Hence, mobile learning applications can be developed as one of the effective revision approaches in preparing the students for examinations.

Evans [6] conducted a study on the effectiveness of mobile learning in the form of podcast revision lectures in higher education. Podcasting involves a series of audio or video files that can be watched or listened over and over again as a preparation before the examination. In the study, 200 first-level undergraduate students were given a revision podcasts after completing a course in Information and Communications Technology as examination preparation. After using the podcasts, students were instructed to answer some survey questions. As a result of the survey, it was found out that the students believed that podcasts are more effective as a learning tool as compared to the previous revision approach which is using textbooks and notes. Podcast is one of the new mobile technologies that give the students an opportunity to do systematic revision for their examinations.

Besides that, Bitesize Mobile [7] has introduced a Java mobile learning quiz application for secondary school students as a tool for revision purposes. The application provides two modes of usage which are online and offline. For online users, they can access the application through certain URL while for offline users, the application is prepared with Java-enabled download whereby students can do the quizzes once the application has been installed in their mobile phones. This application covers three courses which are English, Mathematics and Science. Students can utilize this kind of mobile learning quiz application as a preparation before sitting for the actual examinations.

Developing a mobile learning application has its challenges. Among them are due to the limitations of the mobile devices themselves. As highlighted in Ref. [8], the limitations include small screen size, limited storage memory, navigation mechanisms and others. By identifying the limitations, the mobile learning course content must be developed in such a way that it can fit the small screen size well, consumes minimal mobile phones storage memory and provides the best navigation mechanism to the users in accessing the contents of the application. Thus, for the purpose of this research which is to develop an effective mobile learning revision tool for the course of System Analysis and Development (SAD) at Universiti Teknologi PETRONAS (UTP), several examples of the existing mobile learning applications had been studied in terms of their strengths and weaknesses. This will give the basic ideas of developing a useful mobile learning prototype.

SAD is a descriptive course which is taught to second year Business and Information System (BIS) students in UTP. A lot of concepts are covered in the course whereby students need to understand each concept in order to answer the test or examination questions well. As usual revision technique, short notes will be very helpful in refreshing students’ memory before entering the test or examination hall. The same concept of revision technique was implemented in designing the contents of the application. The small screen size limitation of mobile phones has been the biggest challenge in term of the limited texts which can be inserted in the application development as it will be used to give the understanding about the concepts to the students.

The development of the application which is named as MOSAD took into considerations various teaching and learning theories as well as usability guidelines. The theories included were the cognitive, humanism and information processing theories [9]. This was to ensure that the contents provided by MOSAD will meet the designated objectives of the course. In addition,
several usability guidelines identified by the previous researchers were also considered in the development of MOSAD. The guidelines comprise several aspects which include content, natural usage, flexibility, navigation and consistency [9]. The guidelines were adopted in the application development in order to ensure the application is easy to be used by the users.

In this paper, development and the evaluation of the MOSAD application had been presented. The results show that the students who used the application as a revision tool obtained better marks compared to the students who used different tool for revision. Besides, the results also show that the application is usable as a revision tool for students. The paper is organized as follows: Section 2 discusses the development of MOSAD application; Section 3 presents the testing of MOSAD application; Section 4 is discusses the analysis of the findings; Section 5 and 6 give conclusion and future works.

2. Development of MOSAD Application

System development methodology is important in improving the quality and the productivity of a developed application. Therefore, for MOSAD, its development life cycle model has been developed in order to assist the development of the course content for the mobile learning environment. MOSAD’s development life cycle model adopted ADDIE development approach which contains five phases: analysis, design, development, implementation and evaluation. Fig. 1 shows the MOSAD development life cycle. The analysis phase for the development of the prototype was to identify the weaknesses of the current revision styles, types of mobile phones used by the higher education students, in particular the UTP students, and the equipments provided by the students’ mobile phones. A preliminary study was conducted to obtain the above information as well as to know students’ perceptions on mobile learning implementation in UTP [10]. The survey was conducted among 82 students who took SAD course during semester three in UTP. The basic information of mobile devices that have been used by the students, opinions on current learning practices and also the opinions regarding the mobile learning implementation in the current learning practices especially in the SAD course were gathered from the survey.

Based on the results of the survey [10], majority of the students (92.68%) were using the mobile devices that can support mobile learning environment. In other word, their devices can be connected to the Internet. Other than that, the students believed that mobile learning utilization is more effective as compared to current learning practices according to the overall mean of the questionnaire results, 4.2175 and 3.3544 respectively.

Based on the results of the first phase, the second phase has proceeded with the design of the application content. The topic on Project Initiation which is one of the topics in the SAD course has been selected to be the content which needs to be focussed for the mobile learning application development. The topic was focussed since there are many fundamental concepts of SAD covered in the topic and students were found to be having hard time to understand and memorize each concept taught. All the theories and guidelines identified [9] were implemented during the design of the structure and the interface of the prototype. Table 1 and Table 2 list the learning theories and guidelines followed and state specifically where they were implemented in the design. The MOSAD Instructional Design Model (IDM) as presented in Fig. 2 was produced during this phase. This model was used to represent the elements that need to be utilized in the application development. The elements include the objective, source, instructional strategy, perpetual navigation, learning approach and pedagogical approach.

The next process in MOSAD’s development life cycle was the development of the complete prototype. The tools used for the MOSAD prototype development were: JAVA JCreator LE, Sun JAVA Wireless Toolkit version 2.5.2 and Microsoft Paint. The prototype has been implemented and evaluated several times during the development stage until it was ready for actual implementation.
Fig. 1   MOSAD development life cycle.

Fig. 2   MOSAD instructional design model.
Table 1  Learning theories implemented in MOSAD.

<table>
<thead>
<tr>
<th>Learning Theories</th>
<th>Implementation in MOSAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Flexible actions can help the users in navigating the application. Some applications provided several actions that perform the similar tasks. It is to give the users several methods or ways in accessing the application. Donnelly and Walsh [14] defined the flexibility as preparing the alternative displays to perform the same function and that additional displays can work as the shortcut functions.</td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
</tr>
<tr>
<td></td>
<td>Consistency</td>
</tr>
<tr>
<td></td>
<td>Natural Usage</td>
</tr>
<tr>
<td></td>
<td>Content</td>
</tr>
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<td></td>
<td>For MOSAD development, the contents were organized in chunks or by partials. By managing the contents in chunks, it can minimize the users’ cognitive load [14]. Usually, smaller screens will slow down the reading speed by disrupting the eye movements’ normal pattern [15]. By designing the contents into chunks, it will ease the users in reading the contents of the application. Besides that, only necessary and important information was inserted in the contents of the prototype [8]. It is to ease the learners in finding the important key points of the contents. Hence, MOSAD development implemented less is more rules in ensuring the contents are accurate and solid [15-17] (refer to Fig. 3 and Fig. 4).</td>
</tr>
</tbody>
</table>

Table 2  Guidelines implemented in MOSAD.

<table>
<thead>
<tr>
<th>Guidelines</th>
<th>Implementation in MOSAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>The MOSAD application was designed in which it is user friendly to the users. User-friendliness can be measured when the users just need few minutes to understand how the application works [16]. In other words, when users facing the application, users will understand the application in several seconds and users know what is going to happen if certain actions done by the users. For example, users will always know if the “Exit” command being clicked, the application exit either closing the application exit to the main page of the application. Thus, MOSAD application was designed using the usual set of commands in the application so that the learners already knew what is going to happen when the commands are clicked. The user friendliness is very important for the users in ensuring the focus is more to the contents learning rather than studying how the application operated.</td>
</tr>
<tr>
<td>Natural Usage</td>
<td>Navigation is a mechanism that is developed in helping the users move from the page or section to the desired pages or sections. The simple navigation mechanism was utilized in the MOSAD application [14]. It is to assist the users in accessing the application easily. Besides, the navigation also always consistent at every page of the application [14] [17]. Buchanan et al. [18] found that consistent navigation will maintain the learner’s pace and retaining users’ learning interest, and it can also minimize the number of keystrokes in performing a task. Donnelly and Walsh [14] also gave the advice for navigation aspect whereby the designed application should avoid the users from scrolling frequently. Generally, by implementing scrolling mechanism into the mobile application will slow down the time for users in accessing and reading the content. In solving this issue, the contents of each page were prepared with number-key-pressed navigation mechanism rather than scrolling mechanism. Users can press the number from keypad in order to move to the desired page number. The number-keypad-pressed not only retain the users reading pace, it also can minimize the number of keystrokes in moving from a page to another desired page (refer to Fig. 3 and Fig. 4).</td>
</tr>
<tr>
<td>Consistency</td>
<td>Consistency is the most basic characteristic in usability interface design principles [19]. In ensuring the consistency of the application, similar information and action had been inserted in the similar position at all MOSAD application pages. Basically, consistency of the application will enhance the user friendliness of the application. It happens when the users already know that every page provides similar sets of actions. Because of that, the users can access the application from any pages or sections easily. Users need lesser time in studying the application and the focus can be used more on studying prepared learning content. Flexible actions can help the users in navigating the application. Some applications provided several actions that perform the similar tasks. It is to give the users several methods or ways in accessing the application. Donnelly and Walsh [14] defined the flexibility as preparing the alternative displays to perform the same function and that additional displays can work as the shortcut functions. For example, MOSAD provides the main menu list for the users to choose the section that need to be studied. After studying that section, users need to exit to main menu list and choose another section, and then users can continue the study. By inserting the shortcut menu list in each page, it will help the users in navigating to the desired section without exiting to the main menu list. Besides, it is also can minimize the number of keystrokes in performing one task (refer to Fig. 7).</td>
</tr>
</tbody>
</table>

Table 2  Guidelines implemented in MOSAD.
MOSAD content application consists of four modules namely Introduction Module, Content Module, Quiz Module and Help Module. For the MOSAD application, the dynamic navigation approach is adopted for giving the users full control when accessing the contents of the prototype. Fig. 3-6 shows the interface examples of the Introduction, the Content, Quiz and the Help Modules respectively.

In the final phase of ADDIE, the evaluation was conducted which consists of preliminary test, post test Quasi Experimental Design (QED) and usability test. The evaluation will be discussed further in the next section.

3. Testing of MOSAD Application

3.1 Objectives

In general, the aim of this study is to assess the students’ performance after using MOSAD application as revision tool as compared to other revision approaches. Thus, the objectives of the testing activity itself are as follows:
(1) To identify usability problems of MOSAD application;
(2) To evaluate the effectiveness of MOSAD application;
(3) To evaluate usability of MOSAD application.

3.2 Methodology

Testing was conducted in several stages in this study. First, preliminary heuristic test was conducted among 5 lecturers who have Human Computer Interaction (HCI) background. The purpose of this test was to get the feedbacks in term of MOSAD application usability and functionality that can be corrected and enhanced. Two of the lecturers have had experienced in teaching the SAD course. The role of these lecturers was to assess and give comments regarding the contents of the MOSAD application through heuristic testing of the application. The results of the preliminary test will be discussed further in the next section.

After the prototype was evaluated by the lecturers and some improvements had been implemented on the prototype, 116 SAD course students performed the post test QED in the second stage of the testing. The test was conducted in a computer laboratory. The students were divided into two groups which are control (X1) and experimental (X2) groups (see Table 3). As MOSAD application was developed mainly as a revision tool for the students, all the 116 students were expected to have already learned the Project Initiation topic delivered by their SAD’s lecturer early in the semester. In this stage of the testing, similar quiz questions based on the said topic were given to all students. The control group students were asked to answer the questions by using any of the current revision tools such as getting the materials from the Internet or reading from books. Meanwhile, the experimental group students have to answer the question using MOSAD application as the revision tool. Results on the performance of both groups are given in the next section.

Finally, after the students had answered the quiz questions using their respective tools, the experimental group students were asked to fill up a survey form to evaluate the usability of MOSAD. The survey questions were adopted from Purdue Usability Testing [20]. The aspects evaluated included consistency, flexibility, users’ memory load, minimal action and learnability. Each aspect comprises of five questions. The students were asked to rate each question on the scale of 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = natural, 4 = agree and 5 = strongly agree). The final results of the survey were used to indicate the usability level of the developed MOSAD prototype. Again, the findings will be discussed in the next section.

4. Analysis of Findings

This section discusses the results of the preliminary testing, post test QED and usability testing. Table 4 presents the qualitative results of the preliminary testing.

<table>
<thead>
<tr>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>It is recommended to add shortcut keys in every page for better understanding and faster learning of the application.</td>
</tr>
<tr>
<td></td>
<td>Embed the sounds as it may increase the users’ understanding.</td>
</tr>
<tr>
<td></td>
<td>Improve the font size and type.</td>
</tr>
<tr>
<td>2</td>
<td>Text colour should be differentiated with the background colour.</td>
</tr>
<tr>
<td></td>
<td>Propose the links as the references in helping students to the further reading.</td>
</tr>
<tr>
<td>3</td>
<td>Differentiate the different levels or importance of the contents via different text sizes and text colours.</td>
</tr>
<tr>
<td>4</td>
<td>Put the Help section in giving information to the users of how to use the application.</td>
</tr>
<tr>
<td></td>
<td>The whole application is very well-structured.</td>
</tr>
<tr>
<td>5</td>
<td>Use standard or normal bullet points.</td>
</tr>
<tr>
<td></td>
<td>“I do not need any help at the second time of using the application since it is familiar.”</td>
</tr>
<tr>
<td></td>
<td>Appropriate pictures or images used.</td>
</tr>
<tr>
<td></td>
<td>The use of text in red may be very wrong for a computer display but it could be acceptable for a smaller display since it can be read clearly in this application.</td>
</tr>
</tbody>
</table>
Usability and Effectiveness of Mobile Learning Course Content Application as a Revision Tool

Based on the given comments by the lecturers, many improvements had been done. However, there are several feedbacks that cannot be entertained. For example, embedding sound into the application. This improvement cannot be done due to the limitations of the software used in developing MOSAD application. Besides, “next” and “back” keys also cannot be implemented in addition to number key-pressed as navigation mechanism since the soft keys are already used as shortcut key. Actually, it is possible to insert “next” and “back” button to the soft keys. However, the addition of the buttons will make the navigation more complex as it requires more keystrokes in order to perform that task which violates one of the guidelines mentioned earlier (refer to Fig. 7).

The quantitative data had been collected from post test QED and usability survey questionnaire. The Parametric Statistic had been used to analyze the quantitative data. The post test was conducted in getting the data regarding the effectiveness of the developed application revision tool as compared to other revision methods. This is to test the following null hypothesis:

Hypothesis (H₀)-There is no significant difference in post test scores between the Control (X₁) and the Experimental (X₂) Groups.

The mean score of the post-test for the control group (X₁) is 5.160 with standard deviation of 1.6704 while the mean score (X₂) for the experimental group is 7.7576 with standard deviation of 0.9456. This comparison shows that group X₂ achieved significantly higher in the post test compared to the control group. The significant (2-tailed) value, p = 0.019, is less than α = 0.05 which implies that the H₀ fails to reject. The summary of the results is shown in Table 5. This means that there is a significant difference in the post test between the two groups. If there is a significant difference in the mean scores of the post test between the two groups, MOSAD prototype can thus be considered as effective.

The independent T-Test also was conducted in order to compare the experimental group mean and control group mean. It is to compare the statistical significance of a possible difference between the means of both groups. The formula used to calculate the t-value is shown below:

![Fig. 7 Number key-pressed versus “next” and “back” navigation mechanism.](image)
Table 5  MOSAD post test results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Sig.(2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td>5.160</td>
<td>1.6704</td>
<td>0.019</td>
</tr>
<tr>
<td>X₂</td>
<td>7.7576</td>
<td>0.9456</td>
<td>0.019</td>
</tr>
</tbody>
</table>

\[
t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}
\]

is the mean of the experimental group;
\(\overline{X}_2\) is the mean of the control group;
\(s_2^2\) is the variance of standard deviation square;
\(n_1\) is a samples size of the experimental group;
\(n_2\) is a sample size of the control group.

After doing the calculation, the t-value is 9.7028 which indicate that there is statistical difference between the means of control and experimental group. As mentioned in the methodology section, there are five factors of usability tested during the evaluation process: consistency, learnability, flexibility, minimal action and minimal memory load. As shown in Fig. 8 [9], the feedbacks from the exit survey conducted to the experimental group (X₂) when analyzed have shown that the flexibility elements have gained the highest mean scores (4.0727) when compared to the other four factors. Flexibility was measured based on the use of several mechanisms in performing similar tasks. The second highest mean score is consistency where the mean is 4.003. This means that the students find that the developed application implemented the same displays at every page of the application. Whereas, the mean score for learnability elements is 3.933, which indicates that the application is fairly easy to operate. Besides, the mean score for the evaluation on the minimal action and minimal memory load aspect are also considerably high which are 3.7667 and 3.7303 respectively. The overall mean score of the usability elements is 3.9012 which are considered high. The results thus indicate that majority of the students agreed that the developed MOSAD application has met the requirement of usability elements as the revision tool.

5. Conclusions

Utilization of mobile learning applications in the education sector has continued to show an increasing trend due to the advancement of technology, hardware as well as software. Mobile learning has largely been accepted as an avenue in providing the students with more independent style of learning.

This paper has presented the development of an m-learning application which can be used as revision tool. Besides, the paper also describes the usability and the effectiveness of the application especially for a descriptive course like SAD. The results show that students who had used the application (MOSAD) to answer quiz questions achieved better results when compared to the control group in the conducted test. The results also show that majority of the students agreed that the developed MOSAD application has met the requirement of usability elements as the revision tool. The overall results of this project proved that the mobile learning course content application will be able to help students in doing revision as a preparation before facing the test or examination.

6. Future Works

For this research, it focused more on development and usability study of MOSAD application as a revision tool. This project still can be expanded by adding several elements inside it. There are two future works that can enhance the developed MOSAD prototype which are integrating dynamic database...
management system and designing the algorithm that can limit number of words or sentences which can be put in one page. By integrating dynamic database management system with the application, the application contents will be more efficient since the information can be stored in the database and user interface will work as a medium of presenting the information. However, by only integrating the application with dynamic database, there is still a limitation that will make the contents per page look messy when the long sentences from the database inserted into the page. Consequently, the usability level of the application will reduce as it makes the users difficult in reading the contents of the application. In order to overcome this problem, an algorithm needs to be identified in limiting the number of words or sentences in a page. By setting the number of words or sentences per page, the application will automatically generate new page when the sentences or words of information in the database exceed the set limit identified in the algorithm.

References