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Development and Usability Evaluation of Platform Independent Mobile Learning Tool (M-LT)

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Abstract**—**Mobile learning (M-learning) integrates mobile devices and wireless computing technology to enhance the current conventional learning system. However, there are constraints which are affecting the implementation of platform and device independent M-learning. The main aim of this research is to fulfill the following main objectives: to develop platform independent mobile learning tool (M-LT) for structured programming course, and evaluate its effectiveness and usability using ADDIE instructional design model (ISD) as M-LT life cycle. J2ME (Java 2 micro edition) and XML (Extensible Markup Language) were used to develop platform independent M-LT. It has two modules lecture materials and quizzes. This study used Quasi experimental design to measure effectiveness of the tool. Meanwhile, questionnaire is used to evaluate the usability of the tool. Finally, the results show that the system was effective and also usability evaluation was positive.

Keywords**—**ADDIE, Conventional learning, ISD, J2ME, M-learning, Quasi Experiment, Wireless Technology, XML

I. Introduction

LEARNING is a process of grasping, digging, or assimilating information or knowledge in day to day life through different systems either intentional or not. Mainly, there are two forms of learning systems which are conventional and distance learning. Conventional learning is the most familiar types of learning in every higher institution. The next one is distance learning which is used to make learning beyond classroom to make learning materials easily accessible. Due to a great advancement of computer devices and Internet, distance learning is changed to electronic learning (E-learning). Meanwhile, the tremendous advancements of wireless technology and mobile devices, mobile learning (M-learning) became in existence which is the next generation of learning system. Therefore, M-learning means using of mobile device as a learning instrument and wireless computing as a communication technology to make learning ubiquitous. The term mobile device includes all mobile and portable devices like cell phones, palms, PDA, pocket PCs, smart phones, and laptops. Although M-learning can offer many opportunities to facilitate and enhance learning, there are factors which affect the implementation of mobile learning system (M-LS) such as purpose of use, constraints of mobile devices, content creation, and wireless technology. Due to these factors, there is no conventional standard to implement and evaluate (M-LS) [1]. Hence, different researchers used different specification based the case study.

In the previous years, researchers were using this application to develop learning tools for different courses for instance, computer network [2], and language [3] to elevate the learning system. In this paper is also mobile learning tool (M-LT) is developed for Structured Programming course.

This paper presents about the design and development of platform independent M-LT for the aforementioned course. Finally, effectiveness and usability of the tool were also evaluated. ADDIE is used as a type of instructional design model (IDM) method which consists of analysis, design, development, implementation, and evaluation. Effectiveness evaluation is used to measure the extent to which the tool met the target and produces the desired outcomes by using pre-test and post-test tool for testing process. In addition, usability testing is used to assesses the level to which the tool operated by its users. As per ISO 9241-11 [4, 5], usability testing constitutes the effectiveness, efficiency, learnability, memorability, simplicity, errors, and satisfaction are the specified set of tasks performed by a specified set of users in a particular environment.

The rest of the paper is organized as follows. In section 2, discusses some related works; Section 3, presents methodology used in this study; Section 4, explains effectiveness and usability evaluations respectively; Section 5, presents about the system and evaluation. Finally, section 8 disuses conclusion and future works.

II. Related Works

The use of Information and Communication Technology (ICT) has improved learning from specific area to everyplace, and specific time to any time. In addition, due to the individualized and collaborative communication nature of the wireless handheld devices which make learning more of flexible through complementing and extending the current ways of learning [6].

However, there are factors which affect the development of M-LS. Some of the factors are limitations of mobile devices, and types of content. Moreover, variety of mobile device is the other factor. Furthermore, the types of mobile device limitations are categorized under either hardware or software.

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For instance, some of the hardware limitations are [6, 7] like memory, processing power, battery consumption, screen size, and resolution. On the other hand, software constraints are types of operating system and technology used to access information either native or browser based. Due to the aforementioned factors that is difficult to develop platform and device independent M-LS. Therefore, to develop effective M-LS that should have either to choose less constrained devices or conduct pilot study to know the features of end users' mobile device which is used to prefer the types of supported devices [8]. This paper adopts both of the above methods to choose the supported devices.

As discussed earlier, there is no conventional standard which is used to develop and examine M-LS. Nevertheless, evaluation has been made according to their capabilities and services using some indicators specified in [1, 9-11] like, types of supported mobile devices, data format, communication technology, learning system, access method, and types of information.

As discussed in the previous section, the term mobile device is used to represent all types of portable devices which are Cell phone, Smart phone [12], PDA [3, 13], notebook [14], Pocket PC [14, 15], Palmtop [16], Tablet PCs [17]. In this research the supported mobile devices are PDA, smart phones and laptop.

Contents are represented using video, audio, picture, and text formats. Due to the minimum storage consumption, text file format is the most familiar and represented in various ways such as, HTML [3], WML [12], and XHTML [2], and XML [18] format. In this research XML is used. Furthermore, IDM is used to translate general principles of learning and instructions into plans for instructional materials and activities in a consistent and reliable fashion [19]. There are numerous IDM types ADDIE, ASSURE, Hannafin and peck, and etc. In this research ADDIE is used to develop M-LT.

Currently, mobile device uses for different applications which are communication between learners and educators [13, 20, 21] to access administrative and educational information, accessing education materials remotely [22-24], playing educational games [25], different activities inside the classroom [14, 26], and field studies [27].

Most of the recent studies are focusing on the use of mobile device as a learning instrument. Amongst the advantages of delivering a subject through mobile devices include it can create a feeling of relaxation, amplify students' willingness to communicate thoughts and feelings, facilitate collaborative communication, and elevate learning system. In this research the developed courseware are used only for educational purpose.

For the past ten years, a number of studies adopted M-learning approach and developed M-LS using different platforms. Anang Hudaya Muhamad Amin, Ahmad Kamil Mahmud, et al. (2006) focuse on the development of M-learning management tool in campus-wide environment using Microsoft.NET infrastructure [14, 17]. Razieh Niazi and Mahmoud [2] present on the design and development of M-learning application using java enabled platform [2, 28] which is platform independent. Therefore, to ensure the platform independence of the tool J2ME and XML are used.

Generally, there are two method that have been applied to effectiveness and usability testing of mobile application [29]: laboratory experiment [30] and field studies [4]. Laboratory experiment used controlled laboratory setting to conduct the survey. On the other hand, field studies allow users to use the application in real environment.

Due to the scope of the study, laboratory experiment was used to test the effectiveness and usability of M-LT. As discussed in the introduction section, usability testing is used to measure the performance and quality of the application using different types of attributes. These are nine generic usability attributes [31, 32]: Learnability [33],

Memorability [34], Errors [34, 35], Efficiency [36], Effectivness [36], Simplicity [37], Comprehensibility [32], User satisfaction [17, 38], and Learning performance. From the above mentioned usability attributes the following four: Learnability, Memorability, Satisfaction, and Simplicity were selected to measure usability of M-LT.

III. METHODOLOGY

As discussed in the Literature Review section, there are a number of IDM to design instructions.

The simplicity, familiarity, and capabilities are the three factors which are used in this research to select the type of IDM. Based on these key factors, M-LT life cycle used ADDIE to design instructions.

The M-LT life cycle consists of Analysis, Design, Development, Implementation, and Evaluation. The overall process for the development of the prototype is depicted in Figure 1.

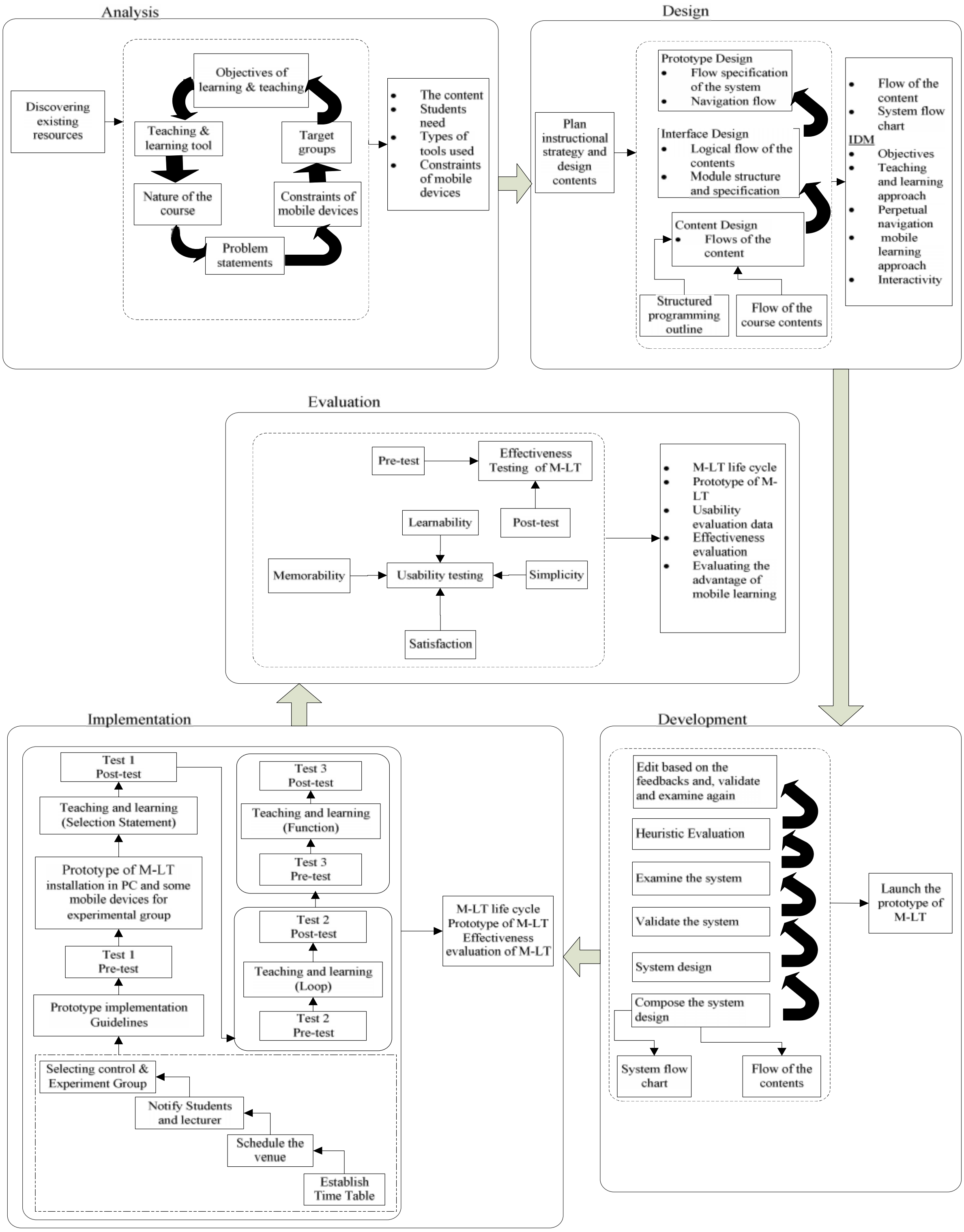

Fig. 1 M-LT Development Phases

As Figure revealed that the need of analysis phase is to gather requirements for the system and making detailed study to understand a topic. Therefore, in this study, the previous related works, the conducted survey, and also the nature of the course are analyzed before the next phase. The preliminary survey was conducted from 90 undergraduate UTP students to get the following data: weakness of conventional learning; identifying contents of the course; their experience and willingness to use the system; selecting samples of students for the implementation and evaluation phase; advantages of mobile learning; limitations of mobile devices; and suggestions either written or orally. The selected topics from the case study course are selection statements, loop, function, and file concepts.

The result of the survey showed that more than two-third of the students (80%) were very eager to use and exercise this trend, [39]. At the meantime, two main challenges were identified which are limitations of mobile devices, and content creations.

From this phase about six types of data were identified as an input: objectives of teaching and learning, the constraints of mobile devices, the problem statements, type of mobile device they own, their experience for mobile learning applications, syllabus contents and the teaching and learning tools; which are used to analyze for the designing phase.

As seen from Figure 1, the second phase involved the designing of the content using the analysis phase output as input. From Figure 2 it can be seen that the flow of the content had been designed based on the course syllabus of the results obtained in the first phase of M-LT life-cycle. These were used also to design the interface and prototype (Refer Figure 3) [40]. As discussed in the above section, both J2ME and XML were used to develop M-LT which are platform independent. All of the above content, interface, and prototype design are input for this phase. IDM is the main output of this phase it can be seen from Figure 4 which consisted of six elements: objectives; teaching and learning approach; perpetual navigation; M-learning approach; and interactivity.

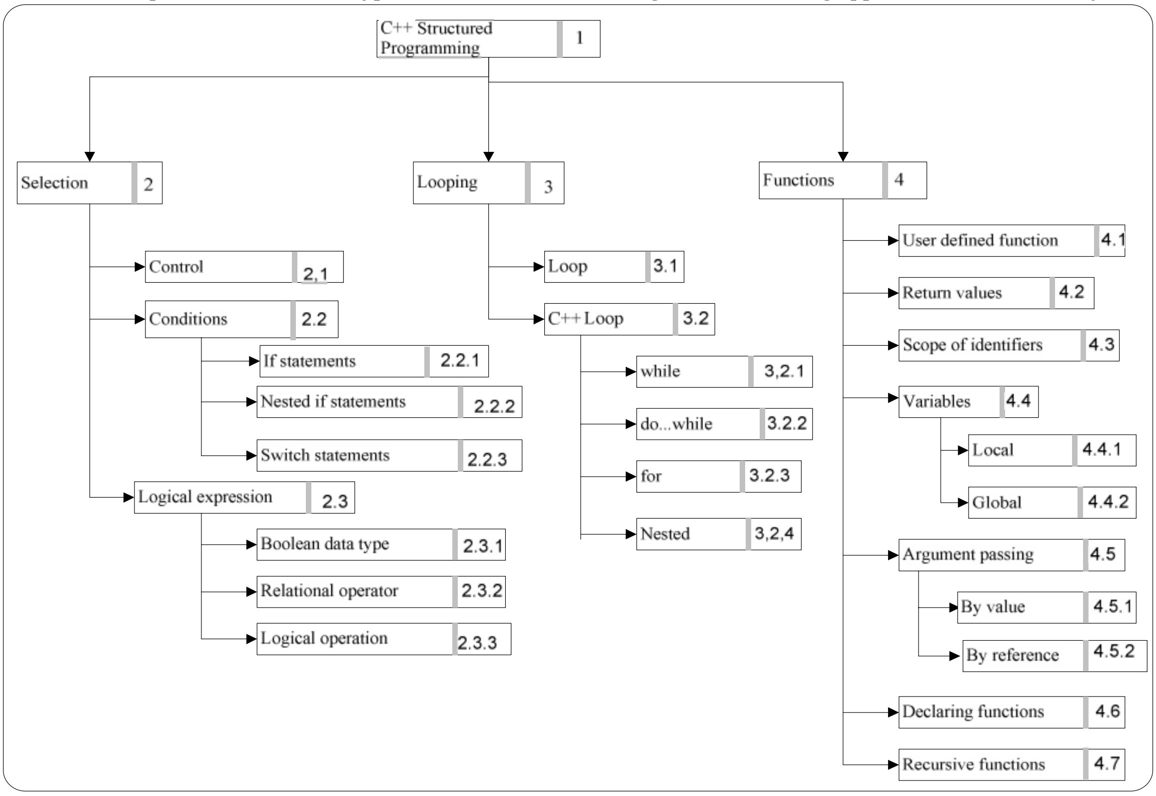

Fig. 2 Content design (course modules)

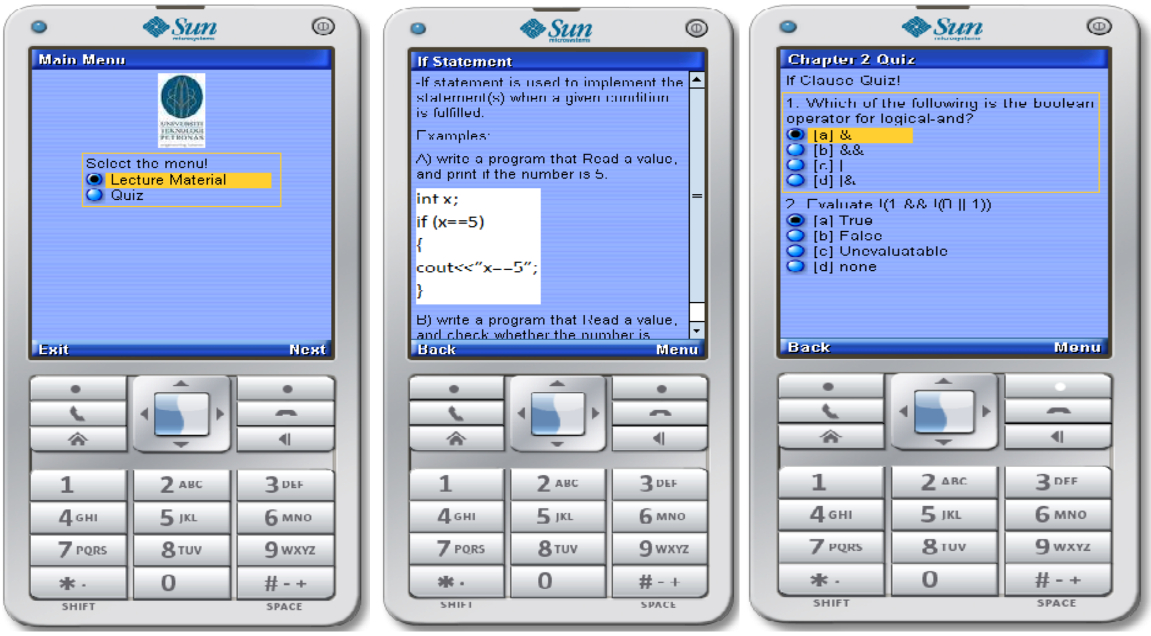

Fig. 3 Interface of the modules

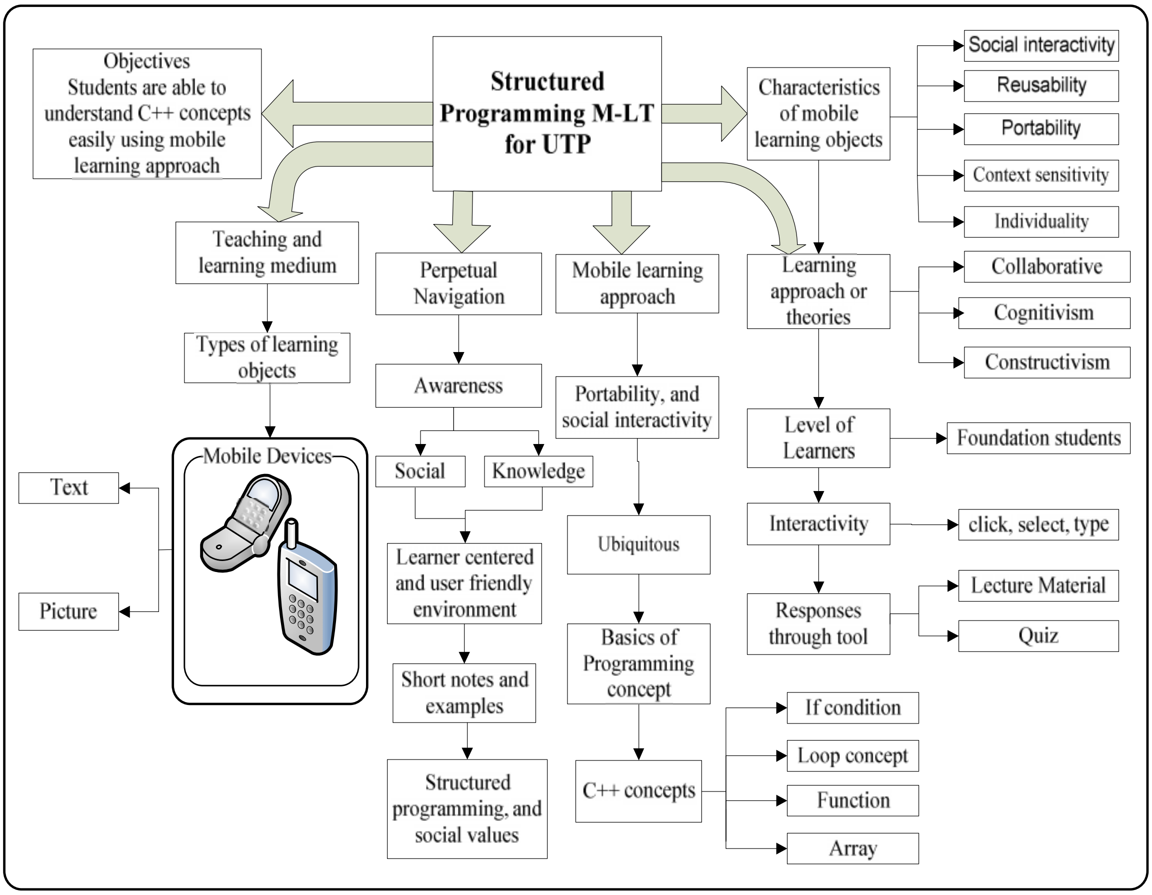

Fig. 4 Instructional Design Model

As seen from the Figure 1 that in the development phase the designed flows of course content and system flow chart are used to compose the system design. Meanwhile, the tool was validated and examined to ensure its functionality. Finally, heuristic evaluation has been conducted and edit based on the feedbacks from experts. The final output of this phase is the final prototype of M-LT. It can be seen from the Figure 1 that in the implementation phase of M-LT cycle, the prototype of M-LT was evaluated through Quasi experimental design (QED). The QED involved two groups: control (Co) and experimental (Ex) groups. The control group attended the treatment of using conventional method. Meanwhile, experimental group used M-LT. Both groups had to sit for the pre-test before learning the topic. After completing the teaching and learning activities through the two types of treatment, students must sit for the post-test to evaluate their performances. As shown in the Table 1, the sample consists of a total of 60 students and 30 students from each of the following programs; Civil Engineering (CE), Mechanical Engineering (ME), Petroleum Engineering students (PE), Chemical Engineering (CHE) students of Foundation program had taken part in the study.

TABLE I
PARTICIPANTS OF THE STUDY

Types of Group	Number of Studnets				TotaL
	ME	CHE	PE	CE	ME+CHE+PE+CE
Controlled Group (C_o)	15	15	15	15	60
Experimental Group (E_x)	15	15	15	15	60
		Total	120		

As discussed earlier in this section, the considered contents of the course are Selection Statements, Loop, and Function. Hence, these topics were used to evaluate the effectiveness of the courseware using pre-test and post-test correspondingly. In addition, there are three tests; Test 1, Test 2, and Test 3 which covered Selection Statement, Loop, and Function respectively. After the Prototype Evaluation Guideline sheet has been examined; the first pre-test was covered from the Selection Statement which is Test 1 was conducted for both selected groups. 120 selected were involved in this study. The students were divided into two groups; 60 students in the conventional class conducted by a lecturer and another 60 students using M-LT application. Both groups had one week to complete this Selection Statement area. The composition of each group that has participated in the experiment is shown in Table 1. At the end of the study, Test 1 post-test was given for both groups. Next, through the same procedure of Test 1, the pre-test of Test 2 was conducted for both groups. After attending lecture for about a week, both groups were conducted post-test. Finally, Test 3 was also conducted in the same procedure for both the pre-test and post-test to evaluate the effectiveness of the system.

As seen from the Figure 1 that evaluation is the last phase of M-LT life cycle. In this phase, the effectiveness evaluation data from the implementation phase were examined. Furthermore, the experimental group was given questionnaires about usability of the tool. The usability factors in the M-LT questionnaires included four attributes, these are: Learnability, Memorability, Simplicity and Satisfaction. Learnability factor used to measure easiness of the system and its capacity to improve students' performance. Memorability was used to measure based on how well users can re-establish the skills of using an application after disconnecting for some time. The satisfaction measurement is to evaluate the students' level of pleasure in using the tool. And simplicity was measured based on user friendliness and quality of menu structures as well as navigation design of the application.

IV. RESULTS

The quantitative data were collected through pre-test, post-test, and questionnaires. Pre-test was used to obtain a baseline performance of students and compare with their post-test result. Finally, usability questionnaires were used to measure the capability of the courseware in providing assistance to the learners. Meanwhile, the qualitative data were collected using subjective questionnaires, and also comments either written or orally which cannot be represented numerically. Qualitative data is used for decision making process. The comparison of the pre-test and post-test will indicate the effectiveness of the M-LT in terms of improving performance. As discussed above, to analyze the quantitative data both effectiveness and usability evaluations were used. The following sections will discuss these two evaluation elements:

A. Effectiveness Evaluation

Effectiveness evaluation is used to determine the efficiency of the courseware through enhancing students' understanding and conducted three tests to measure its efficiency. The maximum mark of each test is five. The evaluation was done by comparing the control and experiment groups. This effectiveness evaluation of M-LT aimed to answer the following questions:

- Does M-LT able to improve learners' comprehension of the Structured Programming course, and enhance conventional learning?
- Does using of mobile devices as a learning instrument been effective to students in learning Structured Programming and other courses which have similar content structure?

Hypothesis is a testable statement which can be two or more possibilities that are contradictory, only one can be true, exhaustive; they cover all possibilities outcomes of a logical conjectured relationship between two or more variables [41, 42]. In this study, there are three hypotheses. In the following sections all of the three hypotheses are analyzed for each the three tests.

1.Pre-test scores between the two groups

Null Hypothesis 1 (H01):- There is no significant difference in the pretest scores between the Control (Co) and Experimental (Ex) groups.

From Table II and Table III it can be seen that the hypothesis and statistical analysis of the pre-test for the three tests respectively. The results presents as follow:

The result of Test 1 shows that the mean score of control group was 1.70 while the experimental was 1.62. However, the significant (2 tailed) value of p = 0.5914 which is greater than α = 0.05. The result failed to reject the null hypothesis H01 and there is no significant difference in the pre-test scores of the both groups. Hence, the null hypothesis for Hypothesis 1 (H01) is accepted.

After conducting the pre-test and post-test of Test 1, Test 2 was given for both groups and their pre-test results have analyzed as follow. The mean scores are 1.62 and 1.50 for both control and experiment groups respectively. The significant difference of p=.75566 which is greater than α = 0.05 implies that there is no significant difference in the mean scores in the pre-test scores for both groups. Thus, the hypothesis is accepted. In addition, the population is suitable to conduct post test.

Following the pre-test and post-test of Test 2, pre-test of Test 3 was conducted. It is used to make the effectiveness test more reliable. As shown the Independent T-Test for H01 of the Test from Table 2 that the mean value of the control group was 1.83 while the experiment group was 1.67. The significant value of p=.25 which is greater than α = 0.05 implies that there is no significant difference in the mean scores of the test. Therefore, the null hypothesis for Hypothesis 1 (H01) is therefore accepted.

In conclusion, the pre-test t-value of the above three tests are greater than α = 0.05 which implies that there is no significant difference in the mean scores of the test. Additionally, it demonstrates clearly that the students' baseline performance is almost in equal level. Hence, the result is favorable to conduct the post-test to measure the efficiency of the system.

TABLE II
PRE-TEST SCORES

Tests	Variables	Mean	SD	t-value	Sig.(2tailed)
Test 1	Pre-test C_o	1.70	0.6189	0.5914	0.539
	Pre-test E_x	1.62	0.8456		
Test 2	Pre-test C_o	1.50	0.5966	0.7566	0.432
	Pre-test E_x	1.42	0.56122		
Test 3	Pre-test C_o	1.83	0.78474	1.1091	0.25
	Pre-test E_x	1.67	0.79547		

Table III demonstrates that the pre-test statistical analysis for the three tests. According to Table 3, the Test 1 result shows that 8.33% of students from Ex and none in Co scored zero out of five. About 38.33% and 36.67% of students from the respective Co and Ex groups obtained one, 53.33% students in Co and 40% students in Ex scored two, and 5% of students in Co obtained three and 15% of students in Ex scored equivalent mark. On the other hand, none of the two groups scored four and five. The results therefore indicate that the sampling is homogenous and students' level of knowledge on the Selection Statements of C++ prior to the treatment was at the same level.

As discussed earlier the next pre-test was Test 2. From Table 3, 3.33% of students from Ex and none in Co scored zero out of five. About 55% and 51.67% of students from the respective Co and Ex groups obtained one, 40% students in Co and 45% students in Ex scored two, and 5% of students in Co obtained three but, none in Ex scored three. On the other hand, none of the two groups scored four and five. The results therefore indicate that homogeneity of the population in the two groups and students' level of awareness towards this area of test almost the same level. Finally, Test 3 was conducted and their results show that 3.33% of students from both Ex and Co groups scored zero. About 30% and 43.33% of students from the respective Co and Ex groups obtained one, 46.67% students in Co and 36.67% students in Ex scored two, and 20% of students in Co obtained three and 16.67% of students in Ex scored equivalent mark. However, none of the two groups scored four and five. Due to the homogenous results of the two groups, the samplings of the groups are favorable to evaluate effectiveness of the tool through conducting post-test.

Generally, as observed the pre-test results for all of the three tests from Table 3, almost all of students scored in the same range and the results were positive to test effectiveness of the courseware through conducting the post-test. In other word, the students' level of knowledge towards these three areas prior to the treatment was almost in the same level.

TABLE III
SPECIFICATION OF THE PRE-TEST MARKS FOR CONTROL AND EXPERIMENT GROUPS

Marks	Tests											
	Test 1				Test 2				Test 3			
	C_o group		E_x group		C_o group		E_x group		C_o group		E_x group	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
0	0	0	5	8.33	0	0	2	3.33	2	3.33	2	3.33
1	23	38.33	22	36.67	33	55	31	51.67	18	30	26	43.33
2	32	53.33	24	40	24	40	27	45	28	46.67	22	36.67
3	5	8.33	9	15	3	5	0	0	12	20	10	16.67
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
Total	60	100	60	100	60	100	60	100	60	100	60	100

2.Post-test scores between the two groups

Null Hypothesis 2 (H02):-There is no significance difference in the posttest scores between the Control (Co) and Experimental (Ex) groups

In the previous sub-section, the pre-test results for all the three tests have discussed in detail. In this sub-section, the respective post-test results of the three tests will analyze. From Table 4 and Table 5 it can be seen that the hypothesis and statistical analysis of the post-test for all of the three tests respectively. In the following paragraphs the results of each test will present.The result of Test 1 hypothesis is given in Table 4. The mean score of the post-test for the control group is 2.85 while the mean score for the experimental group is 4.33. The mean score comparison shows that the experimental group achieved significantly more in the posttest compared to the control group. However, the significant (2-tailed) value, $p = 0.00$, is less than $\alpha = 0.05$ which implies that H02 should be rejected. This means that there is a significant difference in the post-test scores between the two groups; thus M-LT prototype is effective. Due to the features of the courseware and also nature of the contents, Ex group performed better. Therefore, M-learning approach is recommended as one type of learning system to improve learners' performance by complementing conventional learning [6, 14]. The post-test results hypothesis of Test 2 is given in Table 4. The mean score of the post-test for the control group is 2.35 while the mean score for the experimental group is 3.40. Based on the mean score value s' of the two groups, the experiment group achieved significantly more in the post-test compared to the control group. However, the significant (2-tailed) value, $p = 0.00$, is less than $\alpha = 0.05$ which implies that the H02 is rejected. This means that there is a significant difference in the post-test scores between the two groups; thus M-LT prototype is effective. Due to the nature of the contents of which are mentioned in the entire thesis, M-LT learners performed well in their post-test. Therefore, M-learning approach is recommended as one type of learning system to improve learners' performance through making learning ubiquitous. [6, 14]. From Table 4, the post-test hypothesis of Test shows that the mean score for of Co group is 3.72 while the mean score for Ex is 3.20. The mean score comparison shows that the control group achieved significantly more in the post-test compared to the Experiment group. Both groups' mean value is greater than three which shows that the effectiveness of M-LT to add value and complement the current learning system. However, the significant (2-tailed) value, $p = 0.002$, is less than $\alpha = 0.05$ which implies that H02 should be rejected. This means that there is a significant difference in the post-test scores between the two groups; thus control group was scored better. Due to the nature of the content and also constraints of mobile devices as discussed in the Introduction section that makes difficult to cover the entire contents which was appeared in the post-test. Even though, the control group was scored better than the experiment group, but experiment group was also improved their performance using the courseware. Thus, mobile learning is recommended as one type of learning system to improve learners' performance and to complement the conventional learning. As a conclusion, the Ex group performed better in the first two tests. However, due to the aforementioned reasons the Co groups scored better in the Test 3. Hence, to develop and implement mobile learning approach, the nature of the course should be considered. On the other hand, due to the irreplaceable nature of conventional learning system, mobile learning does not have a potential to replace it rather than complementing. However, if leveraged properly, it has a potential to complement and add value.

TABLE IV
POST-TEST SCORES

Tests	Variables	Mean	SD	t-value	Sig.(2tailed)
Test 1	Post-test C_o	2.85	0.73242	11.276	0.000
	Post-test E_x	4.33	0.7051		
Test 2	Post-test C_o	2.35	0.7324	8.4975	0.000
	Post-test E_x	3.40	0.6162		
Test 3	Post-test C_o	3.72	0.9583	3.1288	0.002
	Post-test E_x	3.20	0.8596		

The detailed percentages of the post-test results for the three tests in each group are shown in the following table (Refer Table 5). The following sections will present the analysis of the post-test results of the three tests.Table V depicted that the statistical analysis of the post test results of Test 1 which was scored by the students from both Co and Ex groups out of five. According to Table 5, none of Co and Ex group learners obtained zero while 1.67% (1) and 30% (18) of students from the Co group scored one and two respectively. But, none of Ex group scored one and two. In addition, 50% (30) and only 13.33% (8) from the respective Co and Ex groups achieved three. However, about 18.33% (11) of students in Co group scored four and 40% (24) for Ex group scored the same, and none in Co group while 46.67% (28) in Ex obtained five or full mark. These results clearly demonstrate that Mobile Learning Tool is able to improve the students' performance, which answers the question of "Does using of mobile devices as a learning instrument been effective to students in learning Structured Programming and other courses which have similar content structure?"As discussed above, Test 1 is followed by Test 2. According to Table 5, the statistical analysis of this test post-test results for both groups are analyzed that none of the two groups of students obtained zero, while none in Ex group and 10% (6) of students in Co group achieved one. In addition, 50 % (30) and only 5% (3) of students from the respective Co and Ex groups scored two which means above 60% (36) of Co groups obtained below average. However, about 35% (21) from Co and 51.67% (31) from Ex achieved three, 41.67% (25) of students in Ex group achieved a score of four and only 5% (3) for Co group, and none in Co group obtained full mark (5) while 1.67% (1) obtained it. These indicated that the improvement of experimental students through using M-LT and answer the question of "Does using of mobile devices as a learning instrument been effective to students in learning Structured Programming and other courses which have similar content structure?"The last test to evaluate the effectiveness of the system was Test 3 and Table 4 shows that the statistical analysis of post-test results for both groups. According to Table 4, it can be seen that none of the two groups of students scored zero and one, while only 11.67% (7) and 20% (12) of the students from the respective Co and Ex obtained two which is below average. About 48.34% (29) of students in Ex group achieved three and only 28.34% (17) for Co group, 36.34% (22) from Co and 23.34% (14) from Ex obtained a score of four, and only 8.34% (5) from Ex group scored five while 14 of Co obtained full mark. These results clearly demonstrate that 60% (36) of Co students scored four and five which means students who are using conventional learning were performing well while only 31.67% (19) of students from Ex group. As discussed in Section 2, the nature of the content and also mobile devices limitations especially hardware constraints are the main factors to affect the effectiveness of M-learning approach. Hence, due to the nature of this test 3 section of content that makes difficult to cover the whole area like the above two tests' content, while it affect the effectiveness and students did not score good enough compare to the above tests. But, it is important to enhance teaching and learning system by complementing the conventional learning. As a conclusion, the experiment group was performed in the first two tests, while control group attained in the last test. From this, the reasons behind of these results were the following: nature of the contents, and limitations of devices. In this research, at the time of development the nature of Test 3 lecture materials were lengthy which makes difficult to situate on the mobile devices.

TABLE V
DESCRIPTIVE STATISTICS OF THE MEAN SCORES OF CONTROL AND EXPERIMENTAL GROUPS

Marks	Tests											
	Test 1				Test 2				Test 3			
	C_o group		E_x group		C_o group		E_x group		C_o group		E_x group	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1.67	0	0	6	10	0	0	0	0	0	0
2	18	30	0	0	30	50	3	5	7	11.67	12	20
3	30	50	8	13.33	21	35	31	51.67	17	28.33	29	48.33
4	11	18.33	24	40	3	5	25	41.67	22	36.67	14	23.33
5	0	0	28	46.67	0	0	1	1.67	14	23.33	5	8.33
Total												

3.Increment scores between the two groups

Null Hypothesis 3 (H03):- There is no significance difference in student's increment scores between the Control (Co) and Experimental (Ex) groups.

The result of the three tests' increment hypothesis is given in Table 6. In the following sections, the analysis of the hypothesis will discuss for each of the three tests.

According to Table 6, the result of Test 1 hypothesis is given. The mean score Co group is 1.15 while the mean score for Ex group is 2.72. This comparison shows that experimental group has performed better by using M-LT courseware. The significance (2 tailed) value, p=0.000 is less than α = 0.05, which implies that H03 should be rejected. This shows that there is significant difference in the increment (post-pre test) scores between the two groups. Thus indicates that M-LT is effective. In other word, experimental group performed well and enhanced their performance.

As shown from Table 6 it can be seen that the H03 hypothesis of Test 2. The mean score for increment of Co is 0.85 while the mean score for Ex group is 1.98. This comparison shows that experimental group has performed better by using M-LT courseware. The significance (2 tailed) value, p=0.000 is less than α = 0.05, which implies that H03 should be rejected. This shows that there is significant difference in the increment (post-pre) scores between the two groups. Thus indicates that M-LT is effective. In other word, experimental group performed well in the post-test relative to their pre-test result. Using the same procedures Test 3 results were analyzed. According to Table 6, the mean score for Co increment is 1.88 while the mean score for E group is 1.53. This comparison shows that control group has performed better, but their difference is insignificance. The significance (2 tailed) value, p=0.080 is greater than α = 0.05, which implies that the result is failed to reject the null hypothesis H03 and there is no significant difference in the increment between the two groups. Thus indicates both groups were improved their performance in equal level, even though the controlled group mean value is greater than the experimental group. Therefore, M-LT is effective to complement the conventional learning.

TABLE VI
INDEPENDENT T-TEST FOR $H_0 3$

Tests	Variables	Mean	SD	t-value	Sig.(2tailed)
Test 1	Increment C_o	1.15	0.8987	8.4629	0.000
	Increment E_x	2.72	1.1213		
Test 2	Increment C_o	0.85	0.7988	8.2363	0.000
	Increment E_x	1.98	0.7009		
Test 3	Increment C_o	3.72	0.9583	3.1288	0.080
	Increment E_x	3.20	0.8596		

B. Usability Evaluation

As discussed earlier in the methodology section, there are four usability factors tested during the evaluation process: Learnability, Memorability, Satisfaction, and Simplicity. From Figure 6, it is shown that the mean value (4.02) for the Memorability is the highest score compared to other three factors. This validates that students can re-establish the skill of using an application. The second highest mean score is Learnability where the mean is 3.98. This means that the students find that easy to use and improve their level of performance using M-LT. The mean score for the level of Simplicity is 3.84, which indicates that how M-LT is user-friendly and quality of menu structures as well as navigation design. From the survey, all most all of the students are familiar with hi-tech mobile technology. The level Satisfaction mean score (3.81) is also considerably high, which indicates students' high satisfaction and level of pleasure while using the courseware while and easily level of the system the easiness of the system when students used the courseware. The results indicate that majority of the students agreed that the courseware has met the requirement of usability elements [29] for the learning activities.

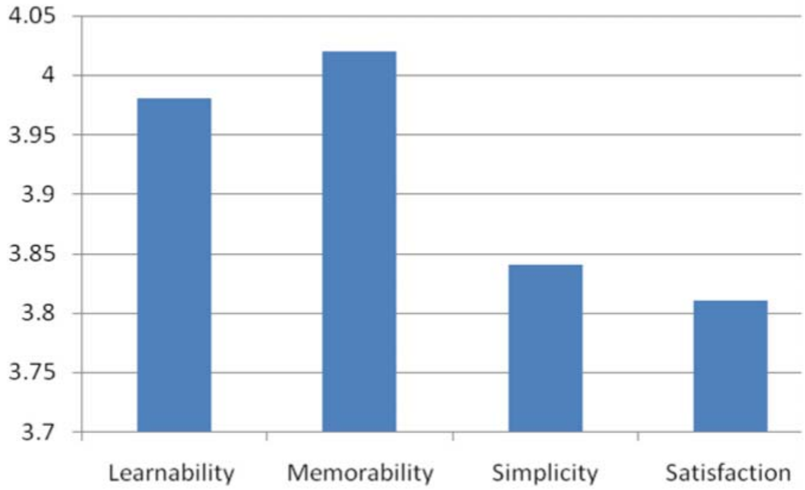

Fig. 6 Mean Score for CLCM

V. DISCUSSION

In this study, the platform independent M-LT is developed using J2ME and XML to store learning materials. Finally, its effectiveness and usability are evaluated using Quasi experimental method and usability attributes respectively.

According to the effectiveness testing results, M-LT is useful and effective through the significant improvement made by the students in the experimental group. Hence, it has a potential to enhance learning system by complementing conventional learning system. Meanwhile, the result of usability evaluation attributes show that students found the tool is easy and user friendly to learn. Therefore, this application meets the requirements usability elements.

VI. CONCLUSION

The main contributions of this study are: adaptation of ADDIE methodology to M-LT life cycle; develop platform independent M-LT; and to evaluate the prototype in terms of effectiveness and usability. For future, researchers have a plan to improve the tool by adding the following features: device adaptive; context-aware model; and Mashup technology (Web Application hybrid).

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