International Journal of Asian Social Science
ISSN(e): 2224-4441/ISSN(p): 2226-5139

Special Issue: International Conference on Teaching and Learning in Education, 2013

journal homepage: http://www.aessweb.com/journals/5007

MEASURING THE EFFECTIVENESS OF TEACHING AND LEARNING PROGRAMMING THROUGH EMBEDDED SYSTEMS

Surizal Nazeri
College of Information Technology, Universiti Tenaga Nasional(UNITEN, Malaysia)
Azizah Suliman
College of Information Technology, Universiti Tenaga Nasional(UNITEN, Malaysia)
Salman Yussof†
College of Information Technology, Universiti Tenaga Nasional(UNITEN, Malaysia)
Nur Shakirah Md Salleh
College of Information Technology, Universiti Tenaga Nasional(UNITEN, Malaysia)

ABSTRACT

An earlier study has shown fewer students are interested in learning programming subjects. Many tertiary educational institutions are faced with a high failure rate in programming courses. In Malaysia the shortage of skilled programmers to meet the job market has caused companies to invite programmers from the foreign countries like Indonesia, India and Vietnam. In generating interest towards programming, a new teaching module has been developed. In this module, students will use electronic devices on an embedded kit to run their programs. This paper discusses the results of an analysis of the experiments carried to test the concept of teaching and learning C programming through embedded systems. Based on the analysis done, the students proved to be more interested in learning programming. Most of the students agreed that the use of electronic tools help them to be more creative as well as increase their interest in programming. It also created opportunities for teamwork when they start doing and discussing the programs development with their friends.

Keywords: Teaching and learning, Programming, embedded systems, Teaching and learning tools, Programming in Malaysian schools, Measuring effectiveness, Interest in programming

† Corresponding author
ISSN(e): 2224-4441/ISSN(p): 2226-5139

1. INTRODUCTION

Programming is one of the most sought after skills in the field of information technology. Currently, electronic devices like smart phones, televisions, music players and many others are the basic equipment's in our daily life and all of these equipments require programs to enable it to operate in accordance to its purpose. As reported by local newspapers, the shortage of skilled programmers is evident worldwide. In Malaysia, government and private companies are forced to import programmers from foreign countries such as India, Indonesia and Vietnam(Hassan, 2009). Realizing the importance to increase the number of skilled programmers, Malaysian government introduced computer programming courses at vocational schools(KPM, 2000). The government also introduced the subject of Information, Communication and Technology as an elective subject for non-vocational schools to allow the students who are not in the vocational stream to learn basic concepts of information technology. Since its implementation in 2003, it has not yet reached its goal in producing a sufficient number of programmers in the country. Research showed that most students who majored in information technology and computer science do not necessarily choose programming as a career because they feel that programming is a difficult and boring subject(Hassan, 2009).

Currently, countries such as Japan, Korea, India and the United States of America (USA) have been producing a lot of skilled programmers. These countries use different approaches of teaching programming other than lecturing. In some parts of USA, programming is taught by using electronic and robotic components in an effort to attract students to programming(Ogasawara and Dodds, 1992). Presumably this method is effective as these countries export their skilled workers to countries that require skilled programmers like Malaysia.

Diversity of teaching methods can help attract students to a topic. Various methods have been introduced by the teachers and researchers in finding the best method to teach programming to students. According to(Matthíasdóttir, 2006), the teaching methods like focusing on lab sessions, recorded lectures, online tests and one-to-one teachings are the suitable methods in teaching. Based on their study, students agreed that the best way to learn programming was to work by themselves on programming coursework, in practical sessions (in the computer room) and on their own with the learning materials. This is consistent with (Bellaby *et al.*, 2003) who states that "…lectures are not a useful way of teaching programming". Both of them suggested the new way to teach programming must be introduced in order to gain students' interest.

In addition, the robot kit is also used in many developed countries to give students early exposure to science-related programming. Since (Papert, 1993) introduced a method of teaching through robotic, awareness of the importance of its use has been increasing year after year. Starting from that, various studies have been conducted to find the best method to incorporate robotic education. The use of robots in education can help teachers to attract students to a topic in the classroom. According to (Goh and Aris, 2008), robots have great potential for pedagogic reasons within education at all levels. In addition, the robotic elements also provide particular opportunities for making accessible, for a wide range of disabled students, practical elements of the curriculum(Mataric, 2004). However, (Cliburn, 2006)reported that only one out of five courses that he taught using robots could be considered successful. He did point out, that part of the reason for the failure in the other courses was due to mechanical problems or lack of access to the robots. This

indicates the use of robots can attract students to learn programming, but it is not practical because students need to handle easily damaged components. In addition, the cost to buy a robot is too high. According to the (McNally, 2006) cost of a robot could reach $300 and it was too high to provide every student with a robot. Since the robots are operated on batteries and are not a precise device, they are also prone to errors and variations in behavior over time. For example, a right turn may be 93 degrees when the batteries are fully charged but only 87 degrees once they are half dead.

In this project we developed a teaching module with an embedded system training kit to teach programming to school children in Malaysia. Embedded Systems Programming (ESP) module is a module which was developed by adapting teaching methods that are based on embedded systems and robotic as it was implemented in other countries. The syllabus of this module followed the Fundamentals of Programming (C Programming) subject and maintains the topics in the syllabus as set by the Ministry of Education (MOE), Malaysia. The difference between this module and the existing module currently used in Malaysian schools is the use of the electronic components such as LED, LCD, 7-segment display and keypad as input and output devices for the programs. The electronic components are supposedly to be the enticing elements of programming in this module. ESP consists of 8 topics where Chapter 1 to Chapter 5 are topics related to the basic of C Programming while Chapters 6 to Chapter 8 are additional chapters for students to learn the basic of Embedded System Programming. This module includes a manual on how the students can use the kit to run their programs.

This paper is organized into four sections. While Section 1 introduces the background of this research, Section 2 will briefly describes the methodology of how the research and experiments are carried out. Section 3 which are actually the main emphasis of this paper, details the results of the testing and assessments of the module and shows the major findings of it. Section 4 ends with a discussion of the findings and concludes with an establishment of a few statements.

2. METHODOLOGY

The major steps that can be clearly distinguished in this research project are module development and module testing and assessment. In this section, we briefly described the first phase of the methodology. For details of this phase please refer to(Suliman and Nazeri, 2012), (Nazeri *et al.*, 2013) and (Suliman and Nazeri, 2013). The testing and assessment methods are described so as to give an understanding of how the results are collected for the analysis.

2.1. Module Development

As mentioned before the modules are developed based on the syllabus of Fundamentals of Programming Language (C Language) but with an introduction to Embedded Systems Programming so the students may be able to use the accompaning training kit to do the partical part of running their progams. Table 1 shows a brief outline of the topics covered in the ESP teaching module. Following the syllabus taxonomy of many programming courses, chapter 1 and 2 starts with the basic theory of programming and problem solving methods. As the basic programming curriculum in Malaysian schools cover structured programming issues until the topics of conditional statements, iterative statements and basic functions, the ESP module content was also formulated to cover these issues. When students start applying the programmings concepts by

solving the problems as related to the embedded devices on the training kit, the programs are executed on the training kits. Problems such as simulating the sequence of traffic light lightings on LEDs on the kits can easily incorporate the structured programming concepts of conditional statements and loops. Through visualization of the problem solution, problem solving becomes more exiciting for the students.

Table-1. A Brief Table of Content for the ESP Teaching Module

Chapter	Topics
1	Introduction to Programming
2	Basic Problem Analysis and Design
3	Fundamentals of C programming
4	Selection Statements
5	Looping Statements
6	Introduction to Embedded System
7	PIC16 Background
8	Embedded Programming

2.2. Module Testing

The teaching modules are tested on students selected from two types of schools, which are the daily (non-boarding and non-vocational) schools and vocational (boarding) schools. Group 1 is a group of 35 students from vocational schools who have been taught basic programming for eight months. Students from this group consist of students from Sekolah Vokasional Balik Pulau and Sekolah Vokasional Shah Alam. Group 2 consists of students from daily schools with a total of 36 students have yet to be exposed to any formal basic programming in schools. Students from this group came from the Sekolah Kebangsaan Derma, Perlis and Sekolah Kebangsaan Bandar Baru Salak Tinggi.

The total teaching time depends on the approval given by the school. Lesson plans are broken down into two teaching options, which are two days or three days of teaching session. For schools that provides two days of teaching session, teaching begins at 8 am and end at 5 pm and the total amount of time for teaching session is 15 hours and for the school that provides three days, teaching session begins at 8 am and ends at 2 pm. Total number of hours for three days is 16 hours.

During the teaching process, students will be divided into groups with each group consist of two to four persons. Each group is provided with one ESP module, one embedded kit and one set of answer booklet to enable students to write answers to each exercise session.

2.3. Assessment Methods

Assessments process is the stage where the students' programming performance will be tested and assessed. In this process, students will be evaluated via three assessment methods to determine their level of understanding. The three methods of assessment are survey, exercises and project.

2.3.1. Survey

Survey contains a number of questions to gauge their interests, understanding and improvement that can be done to the teaching and learning module and kit. This survey is done

after the completion of the teaching and learning process. Each student is given one set of survey questions where they are required to answer and hand back to the instructor.

2.3.2. Exercises

The exercises contain questions to be answered by students based on the topic and it needs to be answered in a group. After each topic covered from the teaching module, related exercises need to be done and answers to the exercise questions need to be recorded in the answer booklet provided. At the end of the course, the group need to return the answer booklet to the instructor for grading.

2.3.3. Project

Project is to identify whether the students can apply what they have been taught so far, to produce a program using the Embedded Kit. Each group was given time of three to four hours to write a program using the embedded kit that utilizes the input and output devices. Scoring does not necessarily depend on the students in producing exciting programs but awarding marks are dependent on the amount of subtopic that can be included in the program and the complexity of the program. The more subtopics and variations of control structure included in a program, the more marks can be obtained. Each group is required to present their project.

3. RESULTS AND ANALYSIS

To facilitate understanding, the results are described in three parts, namely the result of the surveys, the result of the class exercises and the result of the class project. The results will be analyzed and discussed to gain an insight into the students' performance and their interest in this new approach in teaching programming.

3.1. Survey

This survey is intended to obtain the students' opinion on the developed modules in terms of the module layout and the topics covered so that improvements can be made in the future. Apart from that, it is also aimed to find out whether or not the students are interested in programming after the use of this module. The survey was carried out after all the related topics have been taught to the students. Students involved in the survey can be categorized into two groups, students who had not had a formal training in programming, Group 2 and students who have had a formal training in programming, Group 1.

As can be seen from Figure 1, 51% of the students (36 out of 71 students) have never learned basic programming before. By referring to Figure 2, students who have not learned programming, 83.6% or 31 students agree that this module is easy to understand and help them understand the programming topics. 91.9% or 34 students felt that the use of electronic components helps to generate their interest in learning programming because they can manipulate the components to produce creative outputs.

Figure-1. Student experience in programming

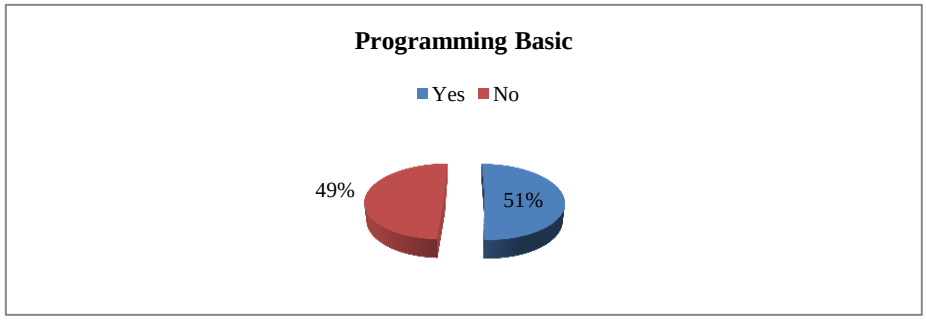


Figure-2. Group 2 - Student understanding and opinions

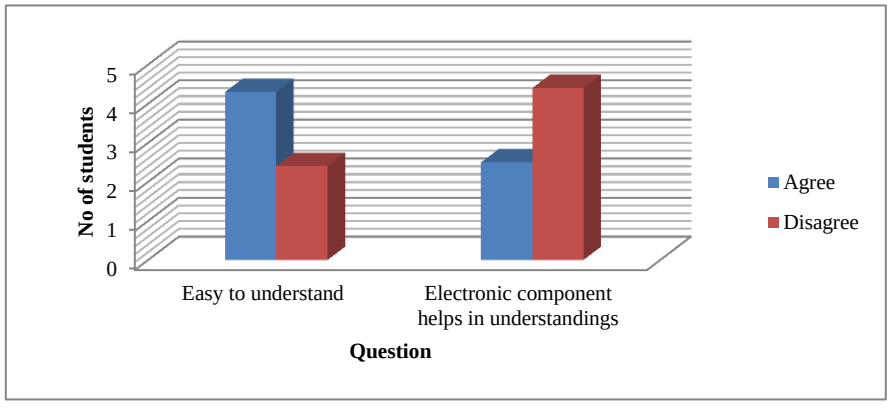
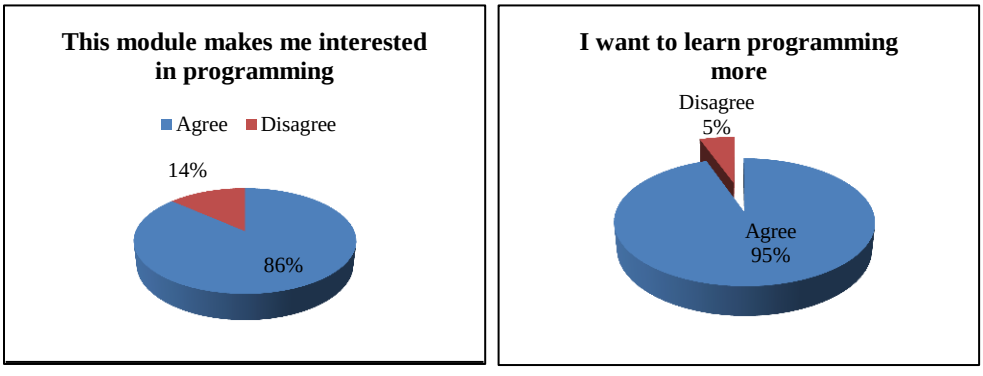


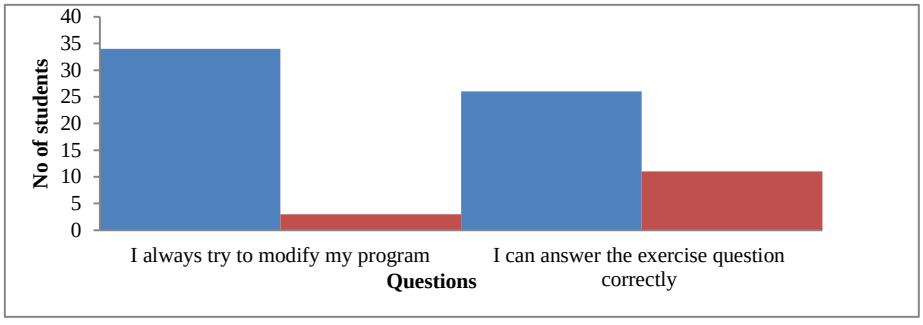
Figure-3. a) Student interest b) Student opinion

(a) (b)



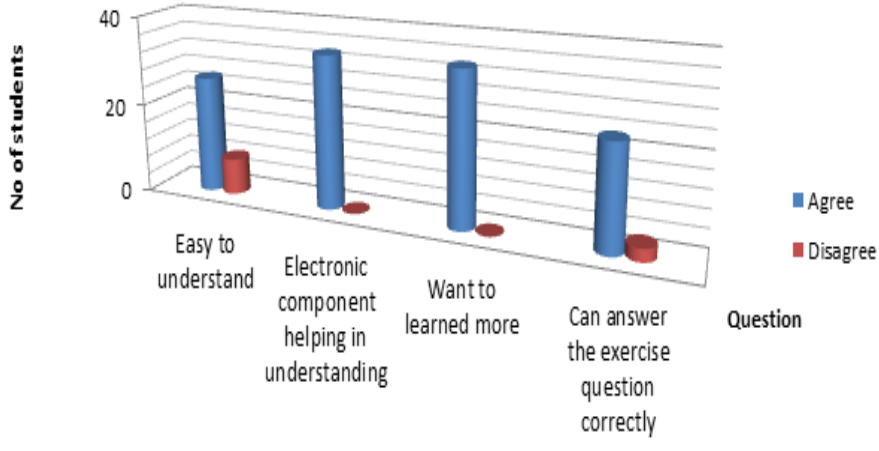
As shown in Figure 3, the ability of the module to get students to be interested to learn programming is proven when 86.5% of the students confirmed this to be the case. Apart from that, 94.6% have expressed their interest to learn more about programming in the future.

Figure-4. Students' Passion in Programming



The passion and interest of the students shown in Figure 4 also revealed when 91.9% of the students actively modifying their program throughout the lab session, while 70.3% of them admitted that they could answer questions correctly.

Figure- 5. Student opinion

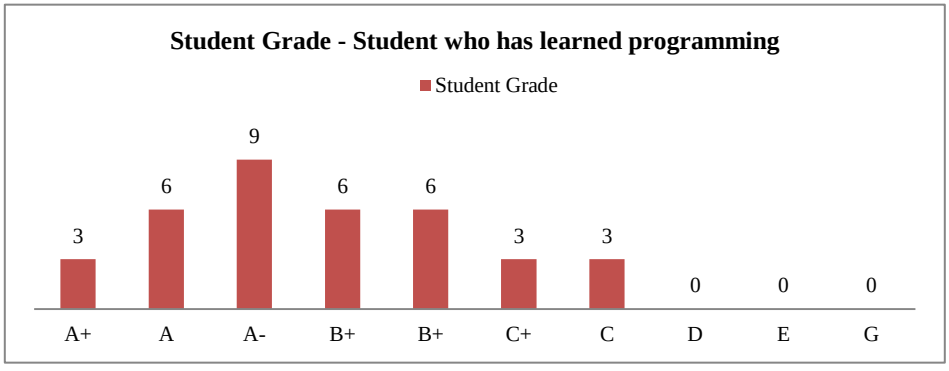


Among the students surveyed, 49% of them (35 out of 71 students) have learned basic programming before. Based on Figure 5, 76.5% or 26 of students in this group think that this module is easy to understand and all of them agreed that the use of electronic components is able to help them to understand the programming topics taught. A total of 97.1% or 33 of the students agreed that this module is able to attract them to learn programming and all of them are interested to learn more in the future. All students also admit they are interested in modifying the program to produce various different outputs and 67.6% or 23 students admitted that they can answer the exercise questions correctly.

3.2. Class Exercises

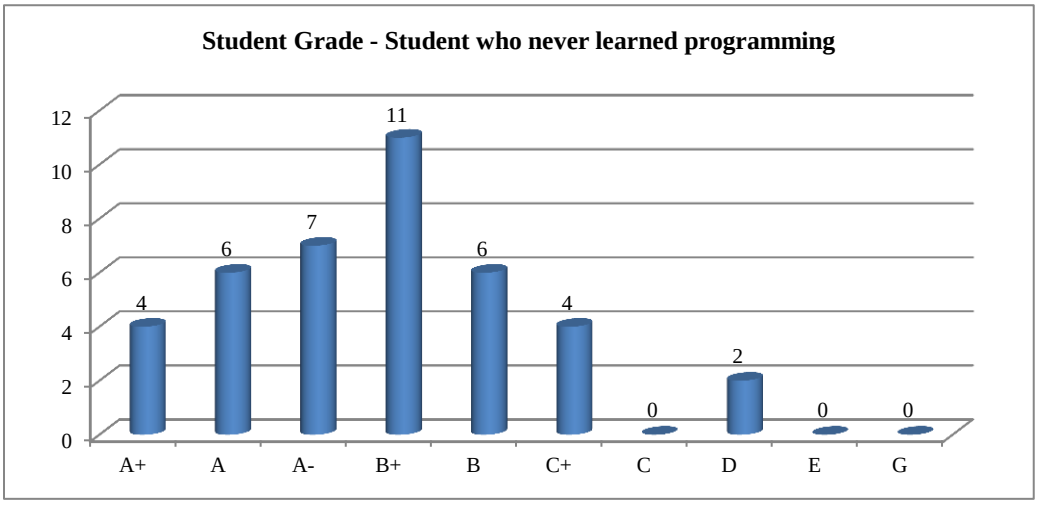
Exercise is a tool for assessing the level of student understanding on the topics taught to them. An exercise is given to each group after the end of each chapter.

Figure-6. Students' Grades – Group 1



Based on the Figure 6, 50% or 18 of the students who have learned basic programming before acquired A- and above for the overall score. Only 16.7% or 3 students in this category obtained the grade C and below. The other else get the grade between B+ and C+.

Figure-7. Students' grades from Group 2

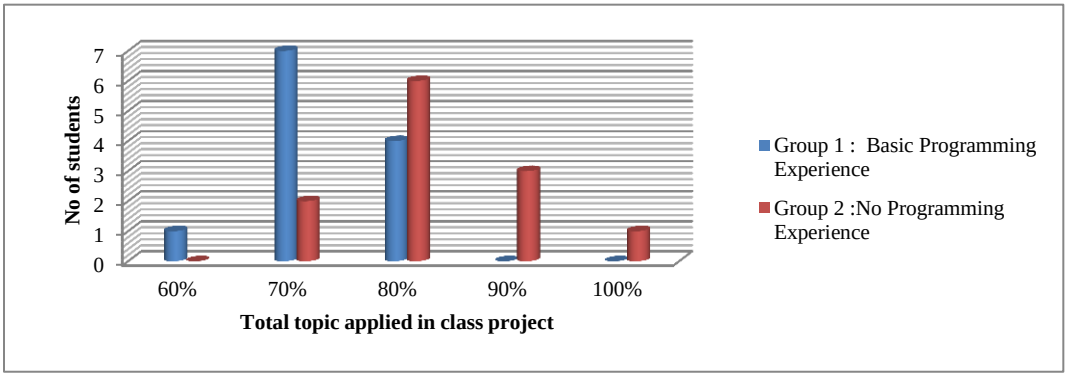


For students who have not learned basic programming before, the student grade is shown in Figure 7. There are 42.5% or 17 students managed to obtain A- and above. However, there are 2 or 5% of the students who obtained a D grade for the exercise. The majority of students only manage to achieve moderate achievement where 52.5% or 21 students obtained the grades between B+ and C

3.3. Class Project

Each group was given four hours to develop their group project. Marks for project are not dependent on the creativity of the students, but focuses on students' understanding of topics that have been taught before.

Figure-8. Percentage of topic applied in student's project



Based on Figure 8, students who have learned basic programming before show good performance. In total there are 10 sub-topics, and there are four groups that managed to apply 80% of the programming techniques taught to them in their program. Another seven groups managed to apply 70% of the programming techniques taught, while the other one group managed to apply 60% of the programming techniques taught in their program. Achievement of students who do not have a previous training in programming is also very encouraging. There is one group that managed to apply all the programming techniques taught to them. Another three groups managed to apply 90% of the programming techniques taught, six groups managed to apply 80% of the programming techniques taught and the other two groups managed to apply 70% of the programming techniques taught.

4. DISCUSSION AND CONCLUSION

The results obtained from these three assessments have shown positive results. In general, the results showed that the students are able to learn programming quite effectively using embedded systems. The use of embedded system to teach programming has also increased their interest in programming to the extent that they would like to learn more. This is proven by their active attitude observed during the process of developing a program in which they are always seen, trying to modify their program if the output does not satisfy them. The interest and enthusiasm of the students are consistent with their performance in class exercises. Overall, student achievement in class exercises have shown encouraging results in which none of them fail (grade F). Almost half of the class managed to get the grade A- and above. This is believe to have proved the effectiveness of this module in increasing student interest and achievement in programming. This statement is further strengthened by the students' achievement in class project which was developed by the students in groups. All groups are able to apply at least 60% of the programming techniques taught to them in their project. This means that they can understand what has been taught to them and apply them in the program that they are developing. Overall, the use of embedded systems in teaching and learning programming is proven to attract student interest in learning programming as well as increase their understanding and achievements. This method provides an alternative to teach programming that can be applied by schools as well as higher learning institutions.

In conclusion, the approach of teaching programming using embedded system as has been practiced by a number of other countries is also suitable to be implemented in Malaysia. Interest in

programming grew because the students are able to see physical outputs of their program offered in the embedded kit. This method has been proven to be effective in attracting student interest in learning programming as well as able to enhance students' understanding and performance compared to the traditional method in teaching programming.

REFERENCES

Bellaby, G., C. McDonald and A.Patterson, 2003. Why lecturer? 4th Annual LTSN - ICS Conference. Galway, Ireland. pp. 228-231.

Cliburn, D. C. 2006. Experiences with the LEGO mindstorms through the undergraduate computer science curriculum. The 36th ASEE/IEEE Frontiers in Education Conference.California: pp. 1-6.

Goh, H. and B. Aris, 2008 . Using robotics in education : Lessons learned and learning experiences. smart teaching & learning: Re-engineering ID, Utilization and Innovation of Technology. Johor Bahru. pp: 2.

Hassan, S. F. 2009. Kerjaya bidang IT lumayan. Kuala Lumpur: Harian Metro.

KPM, K. P. 2000. Pusat perkembangan kurikulum. Putrajaya: Kementerian Pelajaran Malaysia KPM.

Mataric, M. J. 2004. Robotics education for all ages. AAI Spring Symposiumon Accessible, Hands-on AI and Robotics Education. Palo Alto: The AAAI Press. pp: 14

Matthíasdóttir, Á. 2006. How to teach programming languages to novice students? International Conference on Computer Systems and Technologies (CompSysTech'06). Bulgaria.

McNally, G. M.-M. 2006. Do LEGO mindstorms robots have a future in CS education? SIGCSE Bull. pp: 61-62.

Nazeri, S., A. Suliman and N.Salleh, 2013. Measuring the effectiveness of teaching and learning programming through embedded system. International Conference on Teaching and Learning Education (ICTLE). Melaka.

Ogasawara, T. and G. Dodds, 1992. Robotics in Japan: from east to west and outer space to inner space. Computing & Control Engineering Journal, 3(3): 142-148.

Papert, S. 1993. The children's machine: Rethinking school in the age of the computer. New York: Basic Books.

Suliman, A. and S. Nazeri, 2012. The effectiveness of teaching and learning programming using embedded system. 8th International Conference on Information Science and Digital Content Technology (ICIDT). Jeju Island, Korea. pp: 32-36

Suliman, A. and S. Nazeri, 2013. Methods for evaluating the ffectiveness of A C programming teaching tool. International Conference on Computing and Informatics ICOCI. Sarawak. pp: 127-132