Journal of ICT, 13, 2014, pp: 109–124

THE EVALUATION OF AN EMBEDDED SYSTEM KIT AS A C PROGRAMMING TEACHING TOOL

[1]Azizah Suliman & [2]Surizal Nazeri
[1, 2]College of Information Technology, Universiti Tenaga Nasional, Malaysia

azizah@uniten.edu.my; surizal@uniten.edu.my

ABSTRACT

This paper describes the methodology used in evaluating the effectiveness of an embedded system teaching tool for C programming. Teaching programming is one of the major problems among schools and universities. To overcome this problem, a teaching module and an embedded-system training kit for teaching programming to beginners were developed. The teaching module and kit were then tested on selected groups of school children. Focusing more on the testing phase of the research work, this paper gives a detailed account of the testing process and the evaluation method used. The result shows that the students are interested to learn programming using the embedded system.

Keywords: Teaching and learning programming, embedded system, C programming, teaching tools.

INTRODUCTION

Literature and studies have shown that the teaching and learning of programming is a common problem in higher education institutions (Ahdon, 2010; Ford & Venema, 2010; McCracken, Kolikant, Almstrum, Laxer, Diaz & Thomas, 2001). High failure rates in introductory programming courses at tertiary institutions are common (Ford & Venema, 2010; Shukur, Alias, Hanawi, Arsad, 2005; Universiti Tenaga Nasional, 2009). In a research published by Shukur et al. (2005), programming is among the subjects not favoured by the students in the IT and Computer Science streams. The research found that 33.33% of the students got grade D for the computer programming course. According to a study conducted at Universiti Tenaga Nasional (2009), 40.1% of the students were not interested in learning programming (Uniten, 2009). This is evident by statistics which showed that 41 per cent of students do not want to learn other languages after learning the C programming subject. In addition, the same study also found that students only allocated less than two hours per week to learn the programming while 74 per cent did not complete their homework before the class and 50 per cent of the students admitted that they allocated more time to learning other subjects compared to programming. The lack of interest in programming is supported by the observations made by Ahdon (2010) who found that during the question and answer sessions conducted in the process of teaching and learning programming, the students demonstrated a lack of response and showed no interest.

Realising the need to generate more competent programmers in the Malaysian IT market, several measures were introduced by the government. One of the measures was that the Malaysian government, through the Ministry of Education, introduced computer programming courses as elective subjects in the Malaysian secondary schools' curriculum (Kementerian Pelajaran Malaysia, 2000). This initiative is seen as a method to spark interest and awareness in programming among the younger generation. The computer programming course for Vocational Schools teaches subject like the Fundamentals of Programming, Programming and Development Tools that relate to programming. For non-vocational schools, subjects on offer are ICT subjects where one of the modules in the subject introduces students to programming language via Visual Basic. With early exposure to programming, the government hoped the aim to produce and increase the number of programming experts in future would be achieved. Until 2010, there were about 18 vocational schools that offered this subject. However, the number of students sitting for the subjects was still small. In 2009, only 316 students from an overall of 31,166 or 1.01 per cent of vocational students took the Computer Programming course (KPM, 2010) and in 2010, this number decreased to 300 students from an over all of 23,411 or 1.28% of the vocational students (KPM, 2011). In 2011, 416 students from an overall of 23,246 or 1.77% of the vocational students took the Computer Programming course (KPM, 2012).

In Japan, robotics is used in the classroom to stimulate students' interest towards programming. The method obviously gives a positive impact as Japan is recognised as one of the nations with a large number of programmers as well as the biggest producer of embedded systems and robots (Dodds & Ogasawara, 1992). One of the common robotic-programming teaching tools used was Lego Mindstorms and Japanese students have been exposed to the learning tools from the age of 6 or 7 (Dodds & Ogasawara, 1992). The Japanese also teach languages and computer programming to high school students at several private schools (Fujioka, Takada, & Kita, 2005). According to Atmatzidou & Demetriadis (2012), students were more apt to relate programming to real world experience when using the educational robotics method.

In India, embedded systems are used to teach programming to school children, from as early as standard six to nine, and this has also been proven to be effective in producing a large number of skilled programmers (Kannan, 2010). The embedded system is a computer system that combines hardware and software to create a dedicated computer system that performs small tasks, which is encapsulated within the device it controls (Spichkova, Campetelli & Lochmann, 2013). It is a good platform for teaching students programming as the students will be able to visualise and simulate the outputs of the programme on the accompanying hardware. The embedded system is also a field where its applications are usually very small and the output of the system is simple enough to be understood by the students. The use of the embedded system is the best choice in introducing school children to the world of programming and technology (Benson, Arfaee, Kim, Kastener & Gupta, 2011). A context driven approach of teaching, where all the theories taught will be related to real experiments, would be a way of capturing and augmenting the interest of school children to learn and understand programming.

Pair programming is another alternative used as a pedagogical tool in teaching and learning programming courses. It shifts programming learning from a solitary activity into a collaborative learning process (McDowell, Hank & Werner, 2003). A study done by Md-Rejab, Omar, Ahmad and Ahmad (2012) showed that pair programming contributed to better understanding of important knowledge-sharing activities to construct students' skills. Pair programming is able to promote internationalization in the thinking process because both programmers are actively involved in solving programming tasks (Md. Rejab et al. 2012). Using an embedded kit as a platform to teach programming can easily provide an environment for pair programming.

Learning from these success stories, a module for teaching C programming was developed using the embedded system. The teaching tools included a complete tought module that teaches the fundamentals of C programming. The difference this teaching module had was that almost every topic in the module had a related example that could be implemented on an embedded kit. A complete series of lab experiments and exercises for the students to try out were included. A preliminary study in Malaysian schools was done prior to the development of the module. This was discussed by Hawari, Suliman & Othman (2010) and Suliman, Hawari and Othman (2011). Findings from these studies were used in the development of the module. Other publications that discussed the teaching tool were referred to in the works of Suliman, Nazeri and Yussof (2011), Suliman and Nazeri (2012), and Nazeri, Suliman, Yussof and Mohd-Salleh (2013).

THE TEACHING AND LEARNING PACKAGE

The complete teaching and learning C programming package developed for this research is composed of a teaching module and an embedded system training kit. The teaching module is a book containing the learning modules that will be used by students during the teaching and learning process. The module comprehensively contains introductory topics on C programming, related experiments, examples and exercises to test the students' understanding of the topics covered. The topics that the module carries are aligned with the syllabus and the standard specifications that have been set by the Ministry of Education for the programming subject in schools. The already prescribed topics are maintained, the only changes made are the insertion of the introduction to the embedded systems. The additional topics are necessary as the embedded system devices such as LED lights, keypad, LCD and others will act as input and output interfaces for the experiments and examples, in replacement of the input and output devices of a PC as is commonly used. Apart from that, there are additional topics on the Introduction to the Embedded System and the Introduction to Embedded Programming to allow students to obtain some understanding of the Embedded System concepts. The module contains eight topics as shown in Table 1, where students will learn the basics of C programming through the Embedded System.

Table 1

Topics Covered in the Teaching Module

Chapter	Topic
1	Introduction to Programming
2	Basic Problem Solving
3	Fundamentals of C programming
4	Selection Statements
5	Iterative Statements
6	Functions
7	Fundamentals of Embedded System
8	Introduction to Embedded Programming on PIC

Chapter 1 and Chapter 2 only teach the basic topics related to programming and problem solving. Chapter 7 introduces the theoretical concepts of the Embedded System. These three chapters do not require much experiments and programming exercises. Experiments or programme examples are for Chapters 3, 4, 5, 6 and 8. In these chapters, students will be provided with programme examples to enhance their understanding of the experiments. The programme examples provided follow every subtopic discussed in the module and students can run the programme on the embedded kit to observe the output of the programme execution.

Each chapter in this module contains exercises to test the students' understanding. Each subtopic will contain at least three questions that have different solution techniques. The diversity of questions like these is to test the extent of the students' ability to identify problems and find solutions to the questions, based on what they have learned before.

The training kit is a teaching aid that is furnished along with the teaching modules. The training kit will be used by the students to execute and see the output of the programme they have developed. This training kit is designed with a few basic input and output embedded system devices. The devices included in the training kit are the keypad and the push button as input devices and LED, LCD, 7-segments, motor and buzzer as output devices. These devices, which need special functions to operate, will be provided to students through the standard library file that they can include in their programmes, and call when needed.

METHODOLOGY

To evaluate the effectiveness of these modules, a comprehensive assessment had to be carried out. Therefore, the assessment could not be done using a single method. Multiple assessment methods were used. All the methods implemented were in support of each other. In the preparation of the assessment, several things, such as the sample selection and the teaching plan had to be made ready. In the following subsection, we describe the preparation and the process of this evaluation.

The Sample

In representing the population, which is the schools in Malaysia, a careful selection was made. Since the testing phase was not merely surveys or questionnaires but involved intensive trainings, a large sample would not be possible. Due to time, money and work-force constraints, only a very small number of schools were chosen. However, the demography and the grouping of the selected schools in the sample were considered to be well represented of the school population in Malaysia. The syllabi of all schools in Malaysia are controlled by the Ministry of Education, as such any school can be assumed to have the same level of education at a given point. In considering the urban and rural factors that might have effects on the students' performance, two schools were selected from Selangor which were nearer to Kuala Lumpur city and two schools were selected from the northern part of Malaysia. The sample was categorised into two groups. Group 1 had programming experience and Group 2 was without programming experience. Group 1 was considered as a controlled group and the achievement of both groups would be compared at the end of the assessment. The description of the groups is as follows:

Group 1: With eight months of basic programming exposure, languages learned: HTML, PHP and C Programming. Sekolah Vokasional Balik Pulau, Penang and Sekolah Vokasional Shah Alam, Selangor. Total number of students: 36.

Group 2: Without programming background, but took Information, Communication and Technology as an elective subject in their schools. Sekolah Kebangsaan Derma, Kangar, Perlis and Sekolah Kebangsaan Bandar Baru Salak Tinggi, Selangor. Total number of students: 40.

Students from Group 1 were majoring in Computer Programming and were from vocational schools. While Group 2 students took the Information, Communication and Technology (ICT) subject as an elective subject and were from non-vocational school ("sekolah harian").

The Teaching Session

Before the teaching started, the students were divided into groups of 2 to 4 persons. Each group was provided with one ESP module, one embedded kit and one set of answer booklet to enable the students to write the answers in the exercise sessions. The concept of TALK, where the instructor gave lectures and DO, where the students were involved in doing programming-oriented tasks were incorporated in the teaching plan as shown in Table 2. Due to time constraints, only Chapters 1, 2, 3, 4, 5 and 8 were covered. These chapters adequately covered the fundamental topics of C programming and a brief introduction to Embedded Programming where students were exposed to the basic concepts of programming on a PIC16F877 microcontroller. In the earlier part, students used the kit in experimenting with their C programming concepts without the need to worry about the microcontroller programming as they would merely be calling functions from specially made libraries.

Table 2

Teaching Plan

Time (Mins.)	Operations or content	Training methods	Training resources
30	Introduction to the course	Talk	Embedded kit
60	**Chapter 1:** Introduction	Talk	Module and powerpoint slides
30	Quiz and exercise	Do	Quiz/Exercise question
60	**Chapter 2:** Problem analysis & design	Talk	Module and powerpoint slides
30	Quiz and exercise	Do	Quiz/Exercise question
120	**Chapter 3:** Fundamentals of embedded programming	Talk & demonstration Do : Doing experiment	Module, powerpoint slides and embedded kit
30	Quiz and exercise	Do (Write answer in answer booklet)	Quiz/exercise question
90	**Chapter 4:** Selection statements	Talk & demonstration Do: Doing Experiment	Module, powerpoint slides and embedded kit
30	Quiz and exercise	Do	Quiz/exercise question
120	**Chapter 5:** Looping statements	Talk & demonstration Do	Module, powerpoint slides and embedded kit
30	Quiz and exercise	Do	Quiz/exercise question
150	**Chapter 8:** Embedded programming	Talk & demonstration Do: doing experiment	Module, powerpoint slides and embedded kit
30	Quiz and exercise	Do	Quiz/exercise question
120	Project preparation	Do (Developing a programme)	Embedded kit and module
30	Project presentation	Do: Group presentation	Embedded kit
960	TOTAL		

A suitable teaching method for this module is a combination of lecturer-oriented and student-oriented methods. The lecturer-oriented method is a method that needs the instructor to teach and explain the concept to the students and they are required to understand the things that are taught by the instructors to make teaching and learning effective. Chapters suitable for this method are Chapters 1, 2 and 7. The student-oriented method is a method in which students are required to discuss among themselves to solve or learn something. Through this method, students will be given problems or questions and they have to find the solutions to solve the problems. Chapters 3, 4, 5, 6 and 8 provide appropriate practice as students need to produce a programme and display the output through the embedded kit. They will discuss in their groups and then will produce a programme based on the questions given to them.

The Assessments

Assessment is a systematic process or activity to obtain information useful in determining the performance (Looney, 2011). It allows the instructor to interpret the students' achievement limit in an effective and meaningful way. Usually, the scores of the tests required confer evaluation. Formative assessment, or known progressive test is an assessment carried out during the teaching and learning process (Harlen, 2005). Its aim is to track the progress of learning that occurs during a lesson. Typically, formative tests can help teachers to see the effectiveness of teaching and help the development of their students (Sadler, 1989). Formative assessment usually involves various forms of measuring instruments. To assess the cognitive theory, teachers can ask the questions orally, give written work in the form of an essay or objective questions, and other tasks such as doing field research, writing reports, organising projects, creating discussions, and so on (Heflebower, 2010). To measure attitudes, interests and so on, teachers can observe, interview and provide questionnaires.

In this study, the students were assessed in three ways: exercises and quizzes, project and questionnaire. For every topic taught, they were given quizzes and exercises. The exercises and quizzes were graded and the marks were collected and recorded for every individual student.

(a) Quiz

Before the process of teaching and learning started, the students were divided into groups and each group was provided with an answer booklet. Each group was required to answer the questions provided in the answer booklet at the end of each subtopic and chapter. After the teaching session, the answer booklets were collected and all the answers were reviewed and the scores for each group were determined. Questions for Chapters 1 and 2 only covered the programming theory without any questions that required students to develop a programme. Questions for Chapters 3, 4, 5 and 8 had questions regarding the theory and there was also a question that required students to develop a simple programme.

(b) Project

At the very end of the teaching session, each group of students was required to carry out a project. The project was to identify if the students could apply what they had been taught by developing a programme using the embedded kit. Each group was given a time of 3 to 4 hours to write a programme using the embedded kit that should have input and produce output. Scoring did not necessarily depend on the creativity of the students in producing exciting programmes, but were dependent on the amount of subtopics that were included in the programme. The more subtopics in a programme, the more marks were obtained. Each group was required to present their project. Each subtopic had its own marks as shown in Table 3 and groups who had more subtopics in their programmes would get more marks. Students needed to do their projects based on the subtopics listed in Table 3. They could use any subtopic in one programme. The total marks would be calculated based on the number of subtopics incorporated in the programme. Each group was required to present their embedded project after the completion of the teaching session.

Table 3

Marks Distribution for Each Topic

Subtopic	**Marks**
Arithmetic operation Basic input output (printf, SEG, LED, etc…) Variable declaration	1 mark per subtopic
For loop While loop If statement If else statement Logical expression	2 marks per subtopic
Switch	3 marks per subtopic
Every device that used embedded programming (without a library)	4 marks per device

(c) Survey

A survey is a method to get the respondents' view on any issue. A survey was carried out to assess the effectiveness of the module in the interests of students with programming. The results obtained from this survey were analysed together with the quizzes and the embedded projects to get accurate results about the effectiveness of this module. The survey was made at the end of the presentation session of the embedded projects. Each student was given a set of questions and they were allocated 5 minutes to answer all the questions. The survey was collected and analysed.

RESULTS

The analysis of the results was based on the three forms of assessment that had been planned before. All the marks accumulated by the students from the exercises, quizzes and projects were totalled and a common grading scale was used to give each of the student a grade. The analysis was mainly based on the comparison of the performance of the controlled group: Group 1, consisting of students who had been taught programming in school, with Group 2, which had no basic programming knowledge. In general, it can be said that both groups did equally well. No huge gaps were observed in the results of the two groups, though the group who had done programming before performed slightly better than the group who had no programming experience.

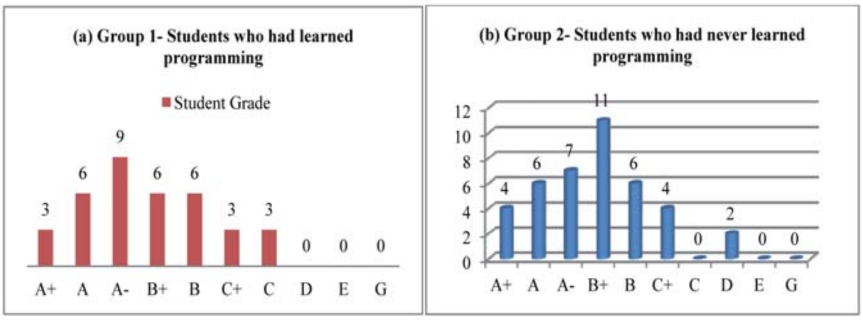

Figure 1. Grade comparisons of the two groups.

Figure 1 compares the students' achievements based on the quizzes answered by them after each topic. Based on the results obtained, it was found that the group that had learned programming recorded better results. However, the difference between the two groups was notably small. Even though 5 per cent of Group 2 obtained a grade D, while 0 per cent from Group 1 obtained that grade, we can see a higher percentage from Group 2 who scored grades A+, A and B+ compared to Group 1. This could be seen in Table 4. The use of the module and the embedded system training kit in teaching the students C programming managed to produce almost as equivalent result for Group 2 students as students from Group 1, who had basic programming experience.

Table 4

Comparisons of Achievements by the Two Groups

Grade	A+		A		A-		B+		B		C+		C		D		E	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Group1	3	8.3	6	16.7	9	25	6	16.7	6	16.7	3	8.3	3	8.3	0	0	0	0
Group2	4	10	6	15	7	17.5	11	27.5	6	15	4	10	0	0	2	5	0	0

In project works, the group that had no basic programming experience seemed to be better at applying what they had learned. This group applied more programming techniques that they had learned and incorporated more I/O devices on the embedded kit into their projects. Hence, their projects showed more creativity and complexity. Based on the observations during the teaching sessions, the embedded system kit helped in invoking the students' tendency to ask questions and challenge themselves to create a better output from their programmes. Since the output of the embedded kit was very visible to others, there was also an obvious element of competitiveness between them. Figure 2 gives an estimation of the topics applied in their projects.

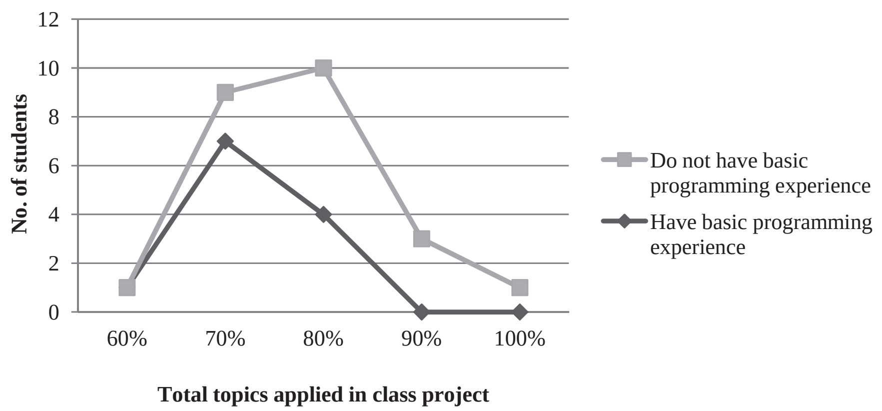

Figure 2. Percentage of topic applied in student's project.

The results obtained through the survey also found that majority of students agreed that this module was interesting and helped them to understand better the topics taught to them. The use of electronic devices in the embedded kit had attracted their attention and encouraged them to modify the code to get a more interesting output. Figure 3 shows the results of the overall survey of both groups.

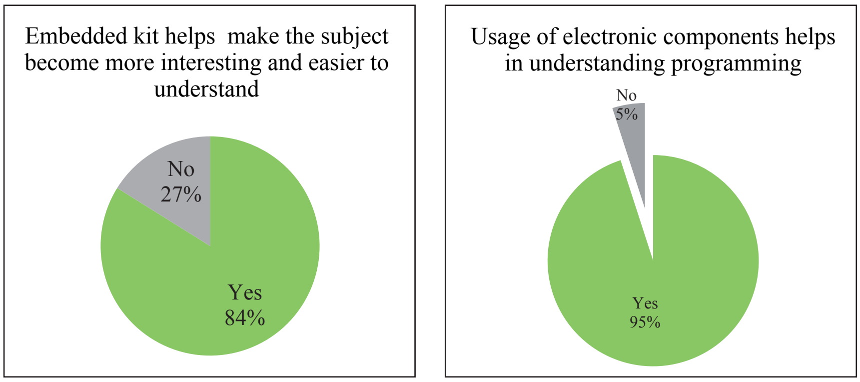

Figure 3. Response to questions on interest to the kit and modules.

Students seemed to be interested in trying something new when using this module. They tried to modify the original code to get something more interesting. In addition, they also admitted they were keen to learn more about programming, particularly about programming electronic equipment other than the devices included in the embedded kit. Figure 4 shows the results of the surveys on the students' interest and enthusiasm.

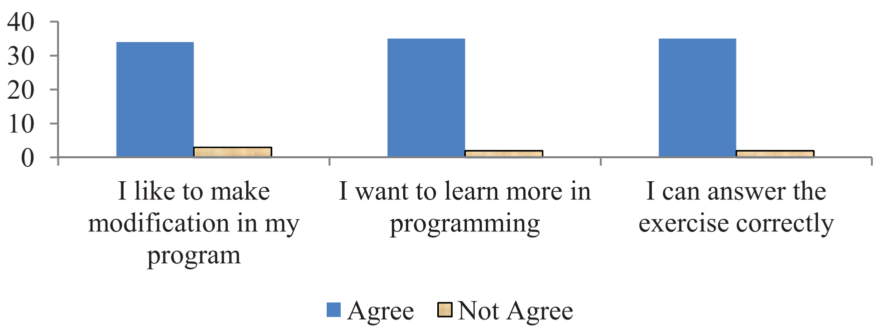

Figure 4. Response of questions reflecting the students' interest and confidence.

The C programming module through the embedded system was developed to improve the methods of teaching programming at the moment. Before the module was developed, some initial steps had been taken such as constructing the survey and interviews with the people who were directly involved in the use of this module. This module was taught to the students and the results on the effectiveness of this module were proven. This can be seen in the admission of the students themselves apart from the quiz and the project results that show the encouraging figure. In any teaching assignment, the success of the teaching methods, modules, and instructors are commonly measured through the achievements of the students in their exams and tests. Grades achieved will reflect whether the teaching sessions have been effective in achieving the outcomes. As such, the results of this study have proven that the teaching tool is effective. We feel that the use of the embedded system as a medium to run the C programmes has proven to be effective in attracting students' interest in learning programming as well as enhancing their understanding. With interest and deep understanding of the concepts taught, the students would naturally excel in their tests and exams. The method of teaching C programming through the embedded system should be considered as an alternative teaching method to the current method as its effectiveness has been proven.

CONCLUSION

The effectiveness of a teaching tool is measured through the performance of the students. In any teaching assignment, the success of the teaching methods, modules, and instructors are commonly measured through the achievement of the students in their exams and tests. Grades achieved will reflect that the teaching sessions have been effective in achieving their outcomes. The evaluation of the embedded teaching tool shows remarkably positive results in terms of the students' assessments results. Using the embedded kit to run all experiments and exercises from the teaching module has created a conducive teaching environment for the students to learn programming. Their projects showed creativity, the teaching sessions, especially the lab sessions, were naturally interactive and their results charted their understanding of the subject taught. In general, we can conclude that the use of the embedded system kit as an aid to teach programming was highly successful in increasing students' interest and understanding.

As the method is as equally important in research as the result, the teaching tool was developed and tested in accordance with the steps prescribed in the research project. Starting with a preliminary study which was conducted in the hope of gathering ideas and requirements for programming teaching tools, the embedded system kit was developed. The teaching module, the experiment and training kit were developed following the basic topics covered in many programming books, with some additional topics to introduce the embedded system. A teaching plan was devised and the module was taught to groups of students. The results were collected and analysed and the findings were documented.

As such, the results of this study have proven that the embedded system kit is an effective teaching tool. We feel that the use of the embedded systems as a medium to run the C programmes has proven to be effective in attracting students' interest in learning programming as well as enhancing students' understanding. With interest and deep understanding of the concepts taught, the students would naturally excel in their tests and exams. The method of teaching C programming through the embedded system should be considered as an alternative teaching method to the current method as its effectiveness has been proven.

REFERENCES

Ahdon, M. F. (2010). *Penggunaan robot soccer sebagai alat bantu mengajar bagi kursus pengaturcaraan C++*. PTSS Digest.

Atmatzidou, S., & Demetriadis, S. N. (2012). *Evaluating the role of collaboration scripts as group guiding tools in activities of educational robotics: Conclusions from three case studies*. In Proceedings of the 2012 IEEE 12th International Conference on Advanced Learning Technologies, ICALT '12, Rome. 298−302. doi: 10.1109/ICALT.2012.111

Benson, B., Arfaee, A., Kim, C., Kastner, R., & Gupta, R. (2011). Integrating embedded computing systems into school and early undergraduate education. *IEEE Transactions on Education, 54*(2), 197−202.

Dodds, C., & Ogasawara, T. (1992). Robotics in Japan: From east to west and outer space to inner space. *Computing & Control Engineering Journal, May*, 143−148.

Ford, M., & Venema, S. (2010). Assessing the success of an introductory programming course. *Journal of Information Technology Education*, *9*, 133−145.

Fujioka, T., Takada, H., & Kita, H. (2005). New challenge of information science education based on PBL using squeak eToy: ISEC-SeT. In P. Kommers & G. Richards (Eds.), *Proceedings of World Conference on Educational Multimedia*, *Hypermedia and telecommunications chesapeake* (pp. 14−21). VA: AACE.

Hasan Shirat, R. (2003, December 9). PMR 2003: 50,520 tempat disediakan di SMT. *Utusan Tutor*.

Harlen, W. (2005). Teachers' summative practices and assessment for learning: Tensions and synergies. *The Curriculum Journal*, *16*(12), 207–223.

Hawari, R., Suliman, A., & Othman, M. (2010). *Factors affecting the success of programming and problems in learning and teaching programming*. Student Conference on Research and Development 2010 (SCoReD 2010), 13 October, UNITEN.

Kannan, S. (2010). *Chennai school to teach robotics*. Retrieved from: http://www.thehindu.com

Kementerian Pelajaran Malaysia (KPM). (2000). *Sukatan pelajaran kurikulum bersepadu sekolah menengah.* Pusat Perkembangan Kurikulum, Putrajaya (White Paper).

Kementerian Pelajaran Malaysia (KPM). (2010). *Analisis keputusan SPM 2009 Sekolah Menengah Teknik dan Sekolah Menengah Vokasional*. Bahagian Pendidikan Teknik dan Vokasional, (BPTV). Retrieved from http://www.scribd.com

Kementerian Pelajaran Malaysia (KPM). (2011). *Analisis keputusan SPM 2010 Sekolah Menengah Teknik dan Sekolah Menengah Vokasional.* Bahagian Pendidikan Teknik dan Vokasional (BPTV).

Kementerian Pelajaran Malaysia (KPM). (2012). *Analisis keputusan SPM 2011 Sekolah Menengah Teknik dan Sekolah Menengah Vokasional.* Bahagian Pendidikan Teknik dan Vokasional (BPTV).

Looney, J. W. (2011). *Integrating formative and summative assessment: Progress toward a seamless system?* OECD Education Working Papers (pp. 58-65). OECD Publishing.

Marzako, R. J., & Heflebower, T. (2010). *Formative assessment and standards-based grading*. USA: Marzano Research Laboratory.

McCracken, M., Kolikant, Y., Almstrum, V., Laxer, C., Diaz, D., & Thomas, L. (2001). A multinational, multi-institutional study of assessment of programming skills of first-year CS students. *ACM SIGCSE Bulletin*, *33*(4), 125−140.

McDowell, C., Hanks, B., & Werner, L. (2003). Experimenting with pair programming in the classroom. *Proceedings of the 8th Annual Conference on Innovation and Technology in Computer Science Education*, *35*(3), 60−64.

Md-Rejab, M., Omar, M., Ahmad, M., & Ahmad, K. B. (2012). Knowledge internalization in pair programming practices. *Journal of Information and Communication Technology 11*, 163−177.

Nazeri, S., Suliman, A., Yussof, S., & Mohd-Salleh, N. (2013). *Measuring the effectiveness of teaching and learning programming through embedded systems*. 2nd International Conference on Teaching and Learning Education (ICTLE2013), Melaka, Malaysia, May, 21−22.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, 18, 119−144.

Shukur, Z., Alias, M., Hanawi, S. A., & Arsad, A. (2004). *Faktor-faktor kegagalan: Pandangan pelajar yang mengulang kursus pengaturcaraan C.* UKM Bangi: Jabatan Sains Komputer, FTSM.

Suliman A., Nazeri S., & Yussof, S. (2011). *A study on teaching and learning of programming subjects at vocational schools in Malaysia*. 1st International Conference on Teaching and Learning Education (ICTLE2011), June, Uniten Bangi, Malaysia.

Suliman, A., Hawari, R., & Othman, M. (2011). *Preliminary study of teaching programming at a Malaysian school*. Proceedings of the 3rd International Conference on Computing and Informatics (pp. 127−132). ICOCI 2011, 8−9 June, Bandung, Indonesia.

Suliman, A., & Nazeri, S. (2012). *The effectiveness of teaching and learning programming using embedded systems*. Proceedings of ICIDT 2012, 8th International Conference on Information Science and Digital Content Technology, 32−36.

Spichkova, M., Campetelli, A., & Lochmann, K. (2013). *Embedded systems*. Technical Report. Munich, Germany: Technische Universität München.

Universiti Tenaga Nasional (Uniten). (2009). *Programming task force: Result of survey questionnaire and suggestions.* Technical Report. College of Information Technology (COIT).